EASTRIDGE TO BART REGIONAL CONNECTOR PROJECT

CAPITOL EXPRESSWAY LIGHT RAIL PROJECT

SPECIFICATIONS – 95% SUBMITTAL

VOLUME 3

Divisions 30-35

JUNE 2020

Santa Clara Valley Transportation Authority

Solutions that move you

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EARTHWORK

PART 1 - GENERAL

1.01 SUMMARY

A. The scope of work outlined in this Section includes the following items of work, as detailed in these Contract Specifications, as shown on the Contract Drawings or reasonably implied therefrom and is not limited to the following items:

1. Staking and grades
2. Existing utilities
3. Earthwork general requirements
4. Subsurface extraction
5. Rough grading and filling
6. Excavation
7. Subgrade preparation
8. Subgrade filling/raising grade
9. Compaction
10. Backfilling
11. Finish grading
12. Common Excavation
13. Common Backfill

1.02 RELATED SECTIONS

A. Section 6.27, Environmental Coordination and Cooperation, of the Special Conditions for Erosion Control

B. Section 01 71 23, Field Engineering, for construction stakes and grades

C. Section 01 78 39, Project Record Documents

D. Section 02 61 00, Contaminated Soil Management

E. Section 31 23 19, Dewatering

F. Section 31 23 43, Structure Excavation and Backfill

G. Section 32 93 00, Planting, for landscape planting and topsoil requirements.

H. Section 33 05 28, Trenching and Backfilling for Utilities for excavating and backfilling for subsurface drainage and utilities

1.03 REFERENCED STANDARDS

A. American Society for Testing and Materials (ASTM):

1. ASTM C131 Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine

2. ASTM C136 Test Method for Sieve Analysis of Fine and Coarse Aggregates

3. ASTM C535 Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine

4. ASTM D422 Method for Particle-Size Analysis of Soils

5. ASTM D653 Terminology Related to Soil, Rods, and Contained Fluids

6. ASTM D1140 Test Method for Amount of Material in Soils Finer Than the 200 (75-um) Sieve

7. ASTM D1557 Test Methods for Moisture-Density Relations of Soils and Soil- Aggregate Mixtures Using 10-lb (4.54-kg) Rammer and 18-in. (457-mm) Drop

8. ASTM D2216 Test Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures.

9. ASTM D2487 Test Method for Classification of Soils for Engineering Purposes

10. ASTM D2974 Test Method for Moisture, Ash, and Organic Matter of Peat and Other Organic Materials

11. ASTM D4253 Test Methods for Maximum Index Density of Soils Using a Vibratory Table

12. ASTM D4254 Test Methods for Minimum Index Density of Soils and Calculation of Relative Density

13. ASTM D4318 Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

B. State of California, Code of Regulations (CCR)

1. Title 8 Construction Safety Orders

C. State of California, Department of Transportation (Caltrans), Standard Test Methods:

1. California Test 217 Method of Test for Sand Equivalent

1.04 DEFINITIONS

A. 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.

B. 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.

C. Earthwork Terminology: Terms used in this Section and not defined herein shall be interpreted in accordance with the definitions given in ASTM D653.

D. Fill: Soil or soil-rock material placed to raise the subgrade or natural grade of the site.

E. Inorganic soil: Soil containing less than two percent by weight of organic material when tested in accordance with ASTM D2974.

F. Optimum Moisture Content: The water content at which a soil can be compacted to a maximum dry unit weight by a given compactive effort.

G. 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.

H. Relative Density: Mass per unit volume as specified in ASTM D4253 and ASTM D4254, as applicable to the soil and test method employed.

I. 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.

J. 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. Of such unstable nature as to be 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.

1.05 SUBMITTALS

A. General: Refer to Special Conditions for submittal requirements and procedures.

B. Submit product data for the following:

1. Backfill

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, Chapter 33, and Appendix Chapter 33, and Structural Chapters 18 and 18A.

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.

G. Waivers for earthwork disposal: Furnish executed waivers from third-party owners of private property to receive surplus earthwork from the project site.

H. 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.

1.06 MEASUREMENT AND PAYMENT

A. Measurement: Only items listed in Bid List will be measured for payment.

1. Roadway Excavation shall be measured by the Cubic Yard.

2. Common Excavation shall be measured by the Cubic Yard.

3. Common Backfill shall be measured by the Cubic Yard.

4. Quantities will be computed, based on the neat lines or pay lines, section profiles, contours, and dimensions indicated on the Contract Drawings.

5. The upper limit for payment of excavations shall be the ground surface as it existed prior to the start of construction operations.

6. The upper limit for payment of backfill, when not indicated, shall be the ground line at the time the excavation is made; except the upper limit for fill shall be the finished grade indicated.

7. 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.

B. Payment:

1. The contract price paid per Cubic Yard for Roadway Excavation shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in roadway excavation as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.
2. The contract price paid per Cubic Yard for Common Excavation shall include full

compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in common excavation as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

3. The contract price paid per Cubic Yard for Common Backfill shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in common backfill as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

1.07 CLASSIFICATION OF EARTHWORK

A. For specification purposes, earthwork shall be classified as follows:

1. Common Excavation: All excavation involved in construction and connections thereto, and any other excavation classified or indicated as common excavation. Excludes structure excavation of various types.

2. Common Backfill: Includes raising or lowering of subgrade 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. Excludes structure backfill of various types.

3. Roadway Excavation: All excavation involved within the existing roadway and connections thereto, and any other excavation classified or indicated as roadway excavation.

4. Subsurface Extraction: Includes removal of abandoned utilities, tanks, walls, foundations, and other miscellaneous subsurface man-made structures that interfere with new construction, 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.

1.08 DESCRIPTION

A. Provide excavation for project improvements; placement of backfill; subgrade and foundation preparation; subsurface extraction of miscellaneous structures and facilities indicated or required to be removed; reconstruction of side slopes, and finish grading.

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, Chapter 4, Subchapter 4 — Construction Safety Orders, and Subchapter 19 — Trench 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.

1.10 QUALITY CONTROL AND ASSURANCE

A. Inspection by Engineer and Other Governing and Regulatory Authorities: Allow the Engineer and other governing and regulatory authorities to perform testing and inspection of materials and practices associated with construction within their jurisdiction on the Worksite during business hours for the purpose of ensuring that the Work is in compliance with the requirements of the Contract Drawings, Contract Specifications, and other local, state and federal laws and regulations.

B. Contractor Quality Control:

1. Sampling, Testing and Inspection:

a. Hire an independent Quality Control Testing Firm to perform sampling, testing, and inspections in accordance with the provisions herein and Section 01 45 00 - Quality Control.

b. 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 Quality Control Testing Firm, as required to comply with the California Building Code, Chapter 33 and Appendix Chapter 33 and Chapters 18 and 18A.

c. Wherever it is specified herein that sampling, testing, or inspection shall be performed by the Contractor, it shall be understood to mean that said sampling, testing, or inspection shall be performed by the Quality Control Testing Firm.

d. Cooperate with and notify the Engineer at least 48 hours in advance of sampling, tests and inspections, being performed by the Quality Control Testing Firm. The Engineer may elect to observe these procedures. Provide samples and facilities for inspection to the Engineer without extra charge if requested.

e. The Quality Control Testing Firm shall collect samples of materials for testing in accordance with the provisions outlined herein and as directed by the Engineer.

C. Engineer Quality Assurance:

1. The Engineer will monitor the implementation of the Contractor's quality control programs through observation, inspection, sampling and testing in accordance with Section 7.49, Certificates of Compliance and Testing, of the General Conditions.

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 6 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 6.27 Environmental Coordination and Cooperation, of the Special Conditions 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. 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 8 inches and raking free of debris and rubble. Rocks exceeding 6 inches in largest dimension and deleterious material shall be removed from the site and disposed of as specified herein under 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.

E. Structure Backfill requirements are specified in Section 31 23 43, Structure Excavation and Backfill.

2.02 FILL AND BACKFILL MATERIALS - SPECIFIC REQUIREMENTS

A. Common Fill and Backfill: 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 D422):

Sieve Opening	Percent Passing, By Weight
6-inch square	100
¾-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 Fill and Backfill: 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 D422):

Sieve Opening	Percent Passing, By Weight
1-inch square	100
3/8-inch square	75 Minimum
US No. 4	20 Minimum
US No. 200	35 Maximum

2. Sand Equivalent (Calif. Test 217): 10 Minimum

3. Plasticity Index (ASTM D4318): 10 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 fill for top 2.5 feet of finished sub grade.

2. Fill for Modifying Grades: Select fill and backfill. Fill for raising grade under pavements shall be subbase material as specified in Section 32 11 17, Aggregate Subbase Courses.

3. Backfill Against Concrete Walls and Waterproofing: Per requirements of Section 31 23 43, Structure Excavation and Backfill.

4. Backfill for Wing Walls, Retaining Walls, and Abutments: Per requirements of Section 31 23 43, Structure Excavation and Backfill.

5. Fill or Backfill Under Supporting Walls and Columns and Similar Locations: Per requirements of Section 31 23 43, Structure Excavation and Backfill.

6. Backfill Where Not Otherwise Indicated: Per requirements of Section 31 23 43, Structure Excavation and Backfill.

2.04 SOURCE QUALITY CONTROL

A. Materials proposed to be used in the Work shall be laboratory tested by the Quality Control Testing Firm 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 or C535 as applicable.

6. Sieve Analysis: ASTM D422, and ASTM C136, 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. 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. Establish all necessary markers, benchmarks, grading stakes, and other stakes as required for restoring original grades, or modified grades where indicated, in accordance with the requirements specified in Section 01 71 23, Field Engineering.

3.02 EXISTING UTILITIES

A. Verify on site the location and depth of all existing utilities and services before performing any excavation work. Perform work in accordance with Section 33 05 28, Trenching and Backfilling for Utilities. Excavation within 3 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. Perform dust control in accordance with Section 6.27, Environmental Coordination and Cooperation, of the Special Conditions.

B. Excavate, handle, test and dispose of contaminated soil in accordance with Section 02 61 00, Contaminated Soil Management.

C. Dewater excavations in accordance in Section 31 23 19, Dewatering.

D. Prevent erosion of the site at all times. Construct temporary berms and dikes and cut temporary swales to promote natural drainage of site in accordance with Section 6.27, Environmental Coordination and Cooperation, of the Special Conditions.

E. Protect exposed soil layers with high moisture content from excessive wheel loads.

F. Do not excavate or remove any material from the work site or right-of-way which is not within the designated excavation, without written authorization from the Engineer.

G. 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.

H. 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.

3. A third-party property may be used as a disposal site, if the Contractor can furnish an executed waiver from the third-party property owner that acknowledges compositions of the fill material and its acceptance.

I. Maintenance of Excavations, Slopes, and Embankments:

1. Where shoring is not used, excavate and remove material outside the limits of the excavation which is unstable and constitutes potential slides, as determined by the Contractor and verified by the Engineer, or material which comes into excavations for any reason, including from the driving of piles.

2. Maintain slopes until 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.

3.04 SUBSURFACE EXTRACTION

A. Remove subsurface facilities and obstructions encountered during excavation only to the extent indicated or as approved by the Engineer.

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 EXCAVATION

A. General Excavation Requirements:

1. Perform excavating as indicated 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. Comply with applicable requirements of CCR, Title 8, Trench Construction Safety Orders.

3. The bottoms of excavations shall be level, firm, undisturbed earth, clean and free from loose material, debris, and foreign matter.

4. Excavate to the lines and grades indicated or as necessary in order to complete the Work.

5. Excavations shall be supported and maintained by providing structural support of earth walls 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.

6. Limits of excavations shall allow for adequate working space for personnel and equipment and as required for safety of personnel. Cut excavations in solid rock accurately to the lines

indicated on the Contract Drawings.

7. 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.

8. 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.

9. Except as otherwise indicated, 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.

10. Excavations for convenience of the Contractor shall be approved by the Engineer.

11. 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 3 feet from the edge of excavations.

12. Unauthorized over excavations for footings and foundations shall be filled with lean concrete to indicated elevations in accordance with City and County Standard Specifications.

13. 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 that cannot be broken up and removed by a backhoe shall be excavated and removed by jackhammering. The use of explosives will not be permitted.

3.06 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 8 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 2 feet over and 10 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 5 to 1 (horizontal to vertical), the existing slope shall be benched at least 6 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.

3.07 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. 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.

D. Finish sub grade to straightedge or template within specified tolerances with the finished surface bladed to a uniform, dense, smooth texture.

3.08 FOUNDATION PREPARATION

A. Complete construction of the excavation support and dewatering systems prior to construction of structure foundations.

B. Avoid disturbing bottom of excavation. If bottom is disturbed, restore and stabilize the bearing foundation with compacted structure 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 6 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 subexcavated to a minimum depth of 12 inches, and the planned elevation shall be re-established by backfilling with structure 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, subexcavation may be omitted.

3.09 FILL FOR MODIFYING ORIGINAL GRADES

A. Compacted fill for modifying original grade to indicated elevation shall be constructed by approved methods. Fill material shall be spread in uniform lifts not exceeding 8 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.

3.10 COMPACTION

A. Compaction Density: Compact each layer of 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. Fill where the Surface will be Bearing Foundation: Class II for full depth.

2. Fill Below Pavements: Class II for full depth.

3. Backfill around Structures: Class II for full depth.

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. Where not otherwise indicated or specified and where structures are not involved, provide Class I compaction to minimize settlement.

C. Do not use compaction equipment or methods that may cause excessive displacement or damage structures.

3.11 BACKFILLING

A. Use materials removed from site excavations if such material meets specified requirements.

B. Backfilling is required at all excavated areas.

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 concrete attains 70 percent of the specified 28-day strength, but not less than 2,500 psi and the concrete has been inspected by the Engineer and authorized for backfilling. Higher minimum strength prior to backfilling shall be used where shown on the Contract Drawings.

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.

I. Do not backfill on or against masonry walls until the concrete on the metal deck supported by masonry walls has been constructed and cured for a minimum of ten days.

3.12 FINISH GRADING

A. Finish grade all areas to elevations and grades indicated. In areas to receive topsoil and landscape planting, coordinate with the requirements of Section 32 93 00, Planting.

3.13 FIELD QUALITY CONTROL

A. Contractor Quality Control: The Quality Control Testing Firm shall perform the following inspections and testing in coordination with the geotechnical engineer employed by the Quality Control Testing Firm:

1. Density per ASTM D2922.

2. Moisture content per ASTM D3107.

3. Compaction per ASTM D1557, Method D, as applicable. Field-testing of soils or compacted fill in place shall be performed in accordance with applicable requirements of ASTM D2922.

4. Frequency of tests shall be in accordance with the Contractor's Quality Plan, but not less than the following:

   a. Expansive Horizontal Areas: One test per 100 cubic yards, or fraction thereof, of fill or backfill placed.

b. Confined Areas and Embankments: One test per every second lift of fill, backfill, or embankment placed.

B. Geotechnical Quality Control: In compliance with the California Building Code, Chapter 33 and Appendix Chapter 33, the Contractor's earthwork operations shall be performed under the observance and inspection of a Quality Control Testing Firm-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.

C. Engineer Quality Assurance:

1. The Engineer will monitor the implementation of the Contractor's quality control programs through observation, inspection, sampling and testing in accordance with Section 7.49, Certificates of Compliance and Testing, of the General Conditions.

2. 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.

END OF SECTION 31 00 00

SECTION 31 23 19

DEWATERING

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements extracting, containing, discharging, and storing ground water which accumulates in excavations during the progress of work.

B. This Section includes designing, furnishing, installing, operating, and maintaining a temporary dewatering and dewatering control system.

C. For work areas with known groundwater contamination, extracted groundwater must undergo treatment during dewatering process prior to discharge into storm or sanitary sewer system.

1.02 RELATED SECTIONS

A. Section 6.27, Environmental Coordination and Cooperation

B. Section 01 78 39, Project Record Documents

C. Section 02 61 00, Contaminated Soils Management

D. Section 31 00 00, Earthwork, for excavation requirements

E. Section 31 23 43, Structure Excavation and Backfill

1.03 REFERENCED STANDARDS

A. Report titled “Preliminary Site Investigation and Hazardous Materials Evaluation”, dated January 2020, by Geocon Consultants Inc.

B. Report titled “Limited Phase II Environmental Investigation Parcel 1214 (Tran & Zhong)”, dated December 2019, by Haley & Aldrich, Inc.

C. Report titled "Limited Phase II Environmental Investigation Parcel 1215 (World Oil)", dated January 2019, by Haley & Aldrich, Inc.

D. Report titled "Phase II Site Characterization Report: Parcel 1216 AutoZone," dated January 22nd 2020, by Burns & McDonnell.

E. Report titled ““Phase II Site Characterization Report: Bohannon 1217 Parcel”, dated December 13th 2019, by Burns & McDonnell.

F. Report Titled "Phase II Site Characterization Report: Parcel 1218 Abdulkariem," dated January 20th 2020, by Burns & McDonnell.

G. Report titled “Phase II Environmental Site Assessment Report – Parcel 1236 and Parcel 1240”, dated December 23rd 2019, by Kennedy Jenks.

H. City of San Jose, Department of Public Works, Standard Specifications July 1992, with Addenda

1. Section 1302-3, Trench Dewatering

1.04 SYSTEM DESCRIPTION

A. The Contractor shall remove all water which accumulates in all excavations during the progress of work so that all work can be done in the dry, unless otherwise approved by the VTA. Excavated areas shall be kept free from water while underground utilities or structures are constructed, while concrete is setting and until backfill has been placed to a sufficient height to anchor the work against possible flotation or leakage.

B. The Contractor shall, at all times, have on the project site sufficient pumping equipment for immediate use, including standby pumps for use in case other pumps become inoperable. Water shall be disposed of in accordance with the detailed requirements specified herein and so as to cause no injury to personnel or the public, damage to public or private property, nor menace to the public health.

C. The Contractor's dewatering system shall be designed to prevent pumping fines from below grade or disturbing materials exposed at the excavation bottom.

D. If the Contractor's methods as approved, include displacing groundwater as concrete or other work is placed in excavations, the Contractor's dewatering system shall capture groundwater as it is displaced and follow the procedures herein for its containment, analysis, and discharge.

E. Contaminated groundwater must be treated if discharging into local storm drain system under a NPDES permit or into sewer system under a Short Term Discharge permit. Contractor is responsible to secure all necessary permits from jurisdictional agency. Contractor is prohibited to discharge any untreated groundwater without the presence of an approved permit/s.

1.05 SUBMITTALS

A. General: Refer to Special Conditions for submittal requirements and procedures.

B. Prior to installation of the dewatering system, submit dewatering plan including shop drawings and design data, indicating the following:

1. The proposed type of dewatering system.
2. Arrangement, location, and depths of system components.
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. Methods of disposal of pumped water.

7. Method of water quality monitoring.

8. Type of filtration and chemical treatment of contaminated water. Refer to Article 3.04E. herein for Contractor's responsibility for treatment of water contaminated in cleaning its dewatering facilities.

C. Submit copies of the special permits required for performing the work of this Section.

D. 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.

1.06 MEASUREMENT AND PAYMENT

A. Measurement: Dewatering shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Dewatering shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in project dewatering, including permitting, groundwater treatment, reporting and monitoring, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefore.

PART 2 – PRODUCTS (Not Used)

PART 3 – EXECUTION

3.01 DEWATERING

A. In addition to the provisions specified herein for dewatering of excavations, trenches shall be dewatered in accordance with Section 1302-3, "Trench Dewatering," of the City of San Jose Standard Specifications.

B. Except as otherwise noted herein, dewatering shall be performed to accomplish a lowering of measured static ground water level to an elevation which is a minimum of 12-inches below the proposed pipe invert.

C. When pumping is required to reduce groundwater levels it shall be accomplished in a manner nondisruptive to traffic, the surrounding neighborhood, and businesses.

D. The Contractor shall be permitted, during the daylight hours of 8:30 AM to 4:30 PM, to use power plants to operate the dewatering pumps. The power plants shall meet all Federal, State, and City requirements for allowable noise limits. During all other hours, power to run the pumps shall be electric and obtained from a PG&E service point, unless otherwise authorized by the VTA. Service points using City electroliers will not be permitted.

E. If a well point system is deemed by the Contractor to be required, the Contractor shall submit a well design to the VTA for approval. Said well design shall be prepared by a geotechnical engineer registered by the State of California and qualified and experienced to perform such design.

F. Groundwater pumping shall not remove fines from below grade. Wells shall be cased, and filter(s) shall be provided to prevent such pumping of fines. If any dewatering well pumps fines, pumping shall be terminated and a new well shall be properly constructed at a different location with a revised design which eliminates the pumping of fines.

G. Contractor shall coordinate with the requirements of Section 6.27, Environmental Coordination and Cooperation, Section 02 61 00, Contaminated Soil Management and Section 31 00 00, Earthwork.

3.02 CONTAINMENT OF GROUNDWATER EXTRACTED

A. The Contractor shall, upon extraction, provide for the containment and storage of all groundwater extracted in the process of construction dewatering. The extracted groundwater shall be stored in a container(s) which shall be locked to prevent accidental or purposeful discharge of the water. The Contractor shall contain and store the water on-site and in such a manner that it will not interfere with the Contractor's existing or continued construction operations. The contained groundwater is subject to the requirements of the Article 3.03, Analysis of Extracted Groundwater, and Article 3.04, Discharge of Extracted Groundwater, herein. Previous testing indicates that the areas identified below contain pollutants that will require storage and treatment prior to discharge:

1. EBRC1214 (Tran): Hydrocarbons encountered in groundwater.

2. EBRC1215 (World Oil): Residual groundwater contamination exists within the target parcel due to past historical spill.

3. EBRC1216 (Autozone): Naturally occurring metals encountered in groundwater.

4. EBRC1217 (Bohannon): Hydrocarbons, metals and VOCs encountered in groundwater.

5. EBRC1218 (S&S Market): Naturally occurring metals encountered in groundwater.

3.03 ANALYSIS OF EXTRACTED GROUNDWATER

A. The Contractor shall be responsible for the periodic sampling of treated groundwater as stipulated in the NPDES or STD permit conditions. Permittee shall secure the necessary samples from influent and effluent side of the groundwater treatment system and must comply with the discharge threshold requirements set forth in the permit condition.

3.04 DISCHARGE OF EXTRACTED GROUNDWATER

A. The Contractor shall not discharge any water which exceeds the discharge requirements set forth in the NPDES or STD permit condition.

B. Subject to the discharge restrictions stipulated in the approved NPDES and STD permit discharge requirements, effluent from dewatering shall be discharged directly into existing storm manholes, where said storm drainage system is in operating condition. The Contractor shall provide conduits to carry said effluent to nearest storm drainage manhole, including a calibrated low flow meter. The Contractor shall confirm that manholes to be utilized are in operating condition. The water shall be released in a manner that will not impact the Contractor's operations.

C. The pH of the discharge shall not exceed 8.5 nor be less than 6.5.

D. In the event that extracted groundwater does not meet the criteria set forth above, the VTA will then provide for the disposal of the extracted groundwater. The storage container with the extracted groundwater will therefore not be available to the Contractor for storage of additionally extracted water until further notice from the VTA. VTA will be responsible for cleaning of any storage containers that the VTA takes custody of as a result of this project; the Contractor will be responsible for cleaning of dewatering piping, pumps, and other dewatering facilities contaminated as a result of this project. The Contractor will be responsible for removing all storage containers from the site, including those cleaned by the VTA.

3.05 STORAGE OF TREATED WATER

A. Storage of water shall consist of doing all work and furnishing all materials and equipment necessary to contain and dispose of all extracted groundwater as required by these technical specifications.

B. Contractor must secure the permission of VTA Senior Environmental Engineer, before using treated groundwater for use as dust control within the project limits.

END OF SECTION 31 23 19

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SECTION 31 23 43

STRUCTURE EXCAVATION AND BACKFILL

PART 1 - GENERAL

1.01 SUMMARY

A. The scope of work outlined in this Section includes the following items of work, as detailed in these Technical Specifications, as shown on the plans or reasonably implied therefrom and is not limited to the following items:

1. Structure excavation
2. Structure backfill
3. Geocomposite drain system

1.02 RELATED SECTIONS

A. Section 6.6.2, Submittal, of the Special Conditions

B. Section 7.43, Submittal of Shop Drawings, Product Data and Samples, of the General Conditions

C. Section 02 61 00, Contaminated Soil Management

D. Section 02 43 13, BRT Ocala Station Relocation

E. Section 03 30 00, Cast-in-Place Concrete

F. Section 31 00 00, Earthwork

G. Section 31 23 19, Dewatering

H. Section 31 66 17, Mechanically Stabilized Earth Walls

1.03 REFERENCED STANDARDS

A. State of California, Department of Transportation (Caltrans):

1.	California Test 202	Method of Test for Sieve Analysis of Fine and Coarse Aggregates
2.	California Test 216	Method of Test for Relative Compaction of Untreated and Treated Soils and Aggregates
3.	California Test 217	Method of Test for Sand Equivalent
4.	California Test 231	Method of Test for Relative Compaction of Untreated and Treated Soils and Aggregates Using Nuclear Gages
5.	California Test 301	Method of Test for Determining the Resistance "R" Value of Treated and Untreated Bases, Subbases, and Basement Soils by the Stabilometer

B. State of California, Department of Transportation (Caltrans), Standard Specifications 2018:

1. Section 19 Earthwork
2. Section 29 Treated Permeable Bases
3. Section 68 Subsurface Drains

1.04 DEFINITIONS

A. Abbreviations:

1. OSHA: Occupational Safety and Health Administration

B. The term “MSE walls” indicates mechanically stabilized earth walls.

C. Basement material: Material in an excavation or embankment under the lowest layer to be placed.

D. Grading plane: Basement material surface on which the lowest layer of subbase, base, pavement, surfacing, or other specified layer is placed.

E. Subbase: Layer of material between a base and the basement material.

F. Structure excavation includes the following:

1. Excavating foundations for structures, including trenches for culverts, pipes, rods, deadmen, cutoff walls, and other facilities.
2. Placing structure backfill where compaction of the structure backfill is not required.
3. Control and removal of water.
4. Installation and removal of facilities required to complete the work unless specified or allowed to remain in place.

1.05 SUBMITTALS

A. General: Submittals for structure excavation and backfill must be made in accordance with the provisions in Section 6.6.2, Submittal, of the Special Conditions, Section 7.43, Submittal of Shop Drawings, Product Data and Samples, of the General Conditions, and these Technical Specifications.

B. Shop Drawings for Potholing:

1. Submit Shop Drawings showing all potholed pipes, sewers, utilities and other facilities. The Shop Drawings must show all survey information at each location, and accurately establish the size, location, elevation, and alignment of the facility as well as the existing grade elevations in the vicinity of the pothole. The Shop Drawings must also include the bearing of the facility alignment, coordinates at the centerline of the facility for pipelines, and the coordinates of the corners of boxes, manholes, and other similar types of facilities.
2. The Shop Drawings must be prepared at 1"=10' scale, using AutoCAD. The Shop Drawings must be sufficiently large and show the following:

   a. Topography
   b. The entire bent and footings
   c. Structures adjacent to the potholes
   d. The track alignment
   e. Other proposed improvements in the vicinity that might be affected by the existence of the existing pipe, sewer, utility or other facility.

3. The Shop Drawings must label all pertinent information relating to the bent, column, footing, track alignment, and other proposed improvements shown including but not limited to bent number, footing dimensions, bent skew, track alignment and stationing, column offsets, and footing elevations. These Shop Drawings must be submitted 30 days prior to any proposed shoring, excavation, or pile driving.

C. Excavation Support Systems Shop Drawings and Calculations:

1. Where support systems, shield systems, or other protective systems are to be used during structure excavations, submit design calculations and Shop Drawings that demonstrate conformance with OSHA regulations. The Shop Drawings and calculations must be stamped and signed by an engineer who is currently registered as a civil engineer in the State of California with expertise in safety engineering.

D. Certificates of Compliance:

1. Submit Certificates of Compliance for each type of aggregate, cement, or asphalt to be used in treated permeable base. If the treated permeable base is provided by a ready-mix supplier, the certificate of compliance must be submitted and signed by the manufacturer of treated permeable base.
2. Submit a Certificate of Compliance for geocomposite drain certifying that the drain produces the required flow rate and complies with these Technical Specifications. The Certificate of Compliance must be accompanied by a flow capability graph for the geocomposite drain showing flow rates and the externally applied pressures and hydraulic gradients. The flow capability graph must be stamped with the verification of an Independent Testing Laboratory.
3. Submit a Certificate of Compliance for each type of engineering fabric.
4. Submit a Certificate of Compliance for each class of aggregate base, drain rock, crushed rock, and backfill material.
5. Certificates of Compliance must include the name, source, and description of all materials used and must be signed by the material supplier certifying that each material item complies with, or exceeds the specified requirements.

E. Laboratory Test Reports:

1. Laboratory test reports must show the name of testing agency, date of testing, types of tests performed and must be signed by a principal of the testing agency who is currently registered as a civil engineer in the State of California. Laboratory tests must not be older than eight months and must certify that the tested materials meet the specified standards.

F. Product Data:

1. Submit product data and application instructions.

G. Treated Permeable Base Quality Control Plan: Submit a Treated Permeable Base Quality Control Plan for treated permeable base to be placed around slotted plastic pipe at the bottom of geocomposite drains in accordance with Section 29, "Treated Permeable Bases," of the Caltrans Standard Specifications.

1.06 QUALITY CONTROL AND ASSURANCE

A. Codes and Standards: Comply with all Federal, State and local codes and safety regulations.

B. Inspection by VTA and Other Governing and Regulatory Authorities: Allow VTA and other governing and regulatory authorities to perform testing and inspection of materials and practices associated with construction within their jurisdiction on the Worksite during business hours for the purpose of ensuring that the Work is in compliance with the requirements of the plans, these Technical Specifications, and other local, state and federal laws and regulations.

C. Contractor Quality Control:

1. Sampling, Testing and Inspection:

   a. Hire an Independent Testing Agency to perform sampling, testing, and inspections in accordance with the provisions herein and Section 6.26, Quality Assurance and Quality Control Requirements, of the Special Provisions.
   b. Wherever it is specified herein that sampling, testing, or inspection must be performed by the Contractor, it must be understood to mean that said sampling, testing, or inspection must be performed by the Independent Testing Agency.
   c. Cooperate with and notify VTA at least 48 hours in advance of sampling, tests and inspections, being performed by the Independent Testing Agency. VTA may elect to observe these procedures. Provide samples and facilities for inspection to VTA without extra charge if requested.
   d. The Independent Testing Agency must collect samples of materials for testing in accordance with the provisions outlined herein and as directed by VTA.

2. Qualifications of the Independent Testing Agency: Refer to Section 6.26, Quality Assurance and Quality Control Requirements, of the Special Provisions.

D. VTA Quality Assurance:

1. VTA will monitor the implementation of the Contractor's quality control programs through observation, inspection, sampling and testing in accordance with Section 6.26, Quality Assurance and Quality Control Requirements, of the Special Provisions.
2. Failure of VTA to detect work or material which is defective or contrary to these Technical Specifications must not prevent later rejection when such work or material is discovered, nor must it obligate VTA for final acceptance.

1.07 MEASUREMENT AND PAYMENT

A. Measurement:

1. Structure Excavation of the various types listed on the Schedule of Quantities and Prices must be measured by the cubic yard.
2. Structure Backfill of the various types listed on the Schedule of Quantities and Prices must be measured by the cubic yard.
3. Structure excavation and structure backfill involved in constructing Capitol Aerial Guideway abutment and bent foundations, must be measured as Structure Excavation (Type D) and Structure Backfill (Bridge), respectively.
4. Structure excavation and structure backfill involved in constructing Story Station Access Structures foundations must be measured as Structure Excavation (Type D) and Structure Backfill (Access Structure), respectively.
5. Structure excavation and structure backfill involved in constructing Story Station Pedestrian Overcrossing bent foundation must be measured as Structure Excavation (Type D) and Structure Backfill (Pedestrian Overcrossing), respectively.

6. Structure excavation and structure backfill involved in constructing the station platform, walkway stairs and ramp structures, and the Signals/Communications House at Eastridge Station must be measured as Structure Excavation (Station) and Structure Backfill (Station).
7. Structure excavation and structure backfill involved in constructing cast-in-place approach walls to the Capitol Aerial Guideway and cast-in-place retaining wall at the southeast corner of Capitol Expressway/Cunningham Avenue must be measured as Structure Excavation (Cast-in-Place Retaining Wall) and Structure Backfill (Cast-in- Place Retaining Wall), respectively.
8. Structure excavation and structure backfill involved in constructing TPSS building foundations must be measured as Structure Excavation (TPSS) and Structure Backfill (TPSS), respectively
9. Structure Excavation (Bridge) includes structure excavation not shown on the Schedule of Quantities and Prices or plans as any other type of structure excavation.
10. Structure Backfill (Bridge) includes structure backfill not shown on the Schedule of Quantities and Prices or plans as any other type of structure backfill.
11. If the pay limits are not shown, the payment quantities for structure excavation and structure backfill of the various types listed on the Schedule of Quantities and Prices must be computed as follows:

    a. Horizontal limits are vertical planes one foot outside the neat lines of the footings or structures without footings.
    b. Upper limit for structure excavation is the original ground surface. Where structure excavation is performed within a roadway excavation or a ditch excavation area, the upper limit is the plane of the bottom and side slopes of the excavated area. In new embankments, the upper limit is the plane of the new embankment at the specified elevation.
    c. Upper limit for structure backfill is the finished grading plane or the finished slope lines.
    d. Lower limit is a plane at the bottom of the completed footings or structures or the lower outside surface of rods or deadmen.

12. Measurement for structure backfill does not include the volume occupied by the new structure.

B. Payment:

1. The contract price paid per cubic yard for the various types of Structure Excavation listed in the Schedule of Quantities and Prices must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in structure excavation, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefor.
2. The contract price paid per cubic yard for the various types of Structure Backfill listed in the Schedule of Quantities and Prices must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in structure backfill, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefor.

C. Full compensation for an increase in depth of structure excavation up to two feet from that shown on the drawings or as specified in these Technical Specifications must be considered as included in the various bid items of Structure Excavation involved and no additional compensation will be allowed therefor. For structure excavation to greater depths than described herein, the unit price of structure excavation outside the limits will not be adjusted unless before removal activities, the VTA authorizes the excavation outside the limits to be change order work or you request the excavation outside the limits to be change order work. When the pay limits of structure excavation are so increased, the pay limits for structure backfill are similarly increased. Unit prices of structure backfill will not be adjusted.

D. Full compensation for an increase in width of structure excavation up to three times the outside width of the footing must be considered as included in the various bid items of Structure Excavation involved and no additional compensation will be allowed therefor. For structure excavation to greater widths than described herein, the unit price of structure excavation outside the limits will not be adjusted unless before removal activities, the VTA authorizes the excavation outside the limits to be change order work or you request the excavation outside the limits to be change order work. When the pay limits of structure excavation are so increased, the pay limits for structure backfill are similarly increased. Unit prices of structure backfill will not be adjusted.

E. Full compensation for designing, constructing, and removing excavation support system and other temporary structures, including the leaving of excavation support system in place where required, must be considered as included in the various bid items of Structure Excavation involved and no additional compensation will be allowed therefor.

F. Full compensation for accommodating structure excavation and structure backfill adjacent to existing pipes, sewers, utilities, and other facilities that are located within three feet or less from the location shown on the drawings, or are located more than six feet clear from the proposed footing or structure, must be considered as included in the various bid items for Structure Excavation and Structure Backfill, or the prices paid for the various contract items of work requiring the excavation or backfill when the excavation or backfill is not paid for separately, and no additional compensation will be allowed therefor.

G. Where the location of an existing pipe, sewer, utility, or other facility is located more than three feet from the location shown on the drawings and is closer than six feet clear to the proposed footing or structure, and if in the opinion of VTA, your method of construction is affected by the location of the facility, the structure excavation will be paid for as extra work. No adjustment will be made in the prices paid per cubic yard for the type of Structure Backfill involved.

H. Where the location of an existing pipe, sewer, utility or other facility is not shown on the drawings and is located closer than six feet clear to the proposed footing or structure, and if in the opinion of VTA, your method of construction is affected by the location of the facility, the structure excavation will be paid for as extra work. No adjustment will be made in the prices paid per cubic yard for the type of Structure Backfill involved.

I. Full compensation for furnishing and installing geocomposite drain system consisting of geocomposite drain, plastic pipe, treated permeable base, filter fabric, and drainage pads, must be considered as included in the various bid items of Structural Concrete involved and no additional compensation will be allowed therefor.

J. Attention is directed to Section 31 23 19, Dewatering, for measurement and payment for dewatering.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Structure Backfill:

1. Structure backfill must be free of organic or other unsatisfactory material.

2. The impervious backfill material must be an authorized earthy material. The sand equivalent requirement does not apply.
3. Structure backfill compacted to a relative compaction of at least 95 percent and material placed behind retaining walls must have a sand equivalent value of at least 20 and comply with the gradation requirements shown in the following table:

Sieve size	Percentage passing
3 inches	100
No. 4	35–100
No. 30	20–100

4. Structure backfill for mechanically stabilized embankment (MSE) must conform to the requirements specified in Section 31 66 17, Mechanically Stabilized Earth Walls.
5. Material from structure excavation not suitable for use as structure backfill may be used to replace imported borrow or other excavated material.

B. Permeable Backfill Material:

1. Permeable material must consist of hard, durable, clean sand, gravel, or crushed stone and must be free from organic material, clay balls, or other deleterious substances.
2. Permeable material must have a durability index of not less than 40.
3. Permeable backfill material for mechanically stabilized embankment (MSE) must conform to the requirements specified in Section 31 66 17, Mechanically Stabilized Earth Walls.

C. Filter Fabric: Filter fabric must be Class A.

D. Geocomposite Drain System: Materials for the geocomposite drain system must comply with the specifications for geocomposite wall drain systems in Section 68-7.02 of the Caltrans Standard Specifications.

1. Treated Permeable Base: Treated permeable base must consist of either asphalt treated permeable base or cement treated permeable base and must conform to the requirements of Section 29, “Treated Permeable Bases,” of the Caltrans Standard Specifications.

PART 3 - EXECUTION

3.01 STRUCTURE EXCAVATION

A. General:

1. Remove any material that comes into an excavation from outside the described limits.
2. Obtain VTA's acceptance of the completed structure excavation before placing any concrete or masonry.
3. Change order work includes the following items of work:

    a. If structure excavation is more than six inches from the depth shown and you request an adjustment for the increased depth
    b. VTA orders an adjustment for a decreased depth.

4. Where shown, remove material below the bottom of MSE wall leveling pads.

B. Water Control and Foundation Treatment:

1. For footings at locations with Structure Excavation (Type D), ground or surface water is expected to be encountered but seal course concrete is not needed.
2. Removal and control of water at excavations must conform to the requirements specified in Section 31 23 19, Dewatering.
3. If no piles are used and footing concrete or other structures are placed on an excavated surface other than rock:

   a. Perform excavation without disturbing foundation material. Dewater the excavation in accordance with Section 31 23 19, Dewatering, if groundwater is encountered and no seal course is used. Continue dewatering activities before and during subsequent excavation. Foundations must be free of water when footing concrete or pipes are placed. Continue dewatering activities as required to prevent damage to the work.
   b. If foundation material is disturbed by excavation activities, damaged by water, or removed for your convenience in dewatering, restore the foundation to a condition at least equal to the undisturbed foundation.

4. If the Engineer determines the undisturbed original material of the excavation is unsuitable, correct it as ordered. This work is change order work.
5. If footing concrete or masonry is placed on rock, fully uncover the rock and remove the surface to sound rock. Level or cut the rock to steps and then roughen it.
6. Pressure grout or treat seams in rock as ordered. This work is change order work.
7. For footings on piles, excavate to the bottom of footings before driving piles or drilling for piling. If swell or subsidence results from pile driving, excavate or backfill the footing area to the grade of the bottom of the footing. If the material under footings would mix with footing concrete or would not support the weight of wet concrete, replace the material with suitable material, install soffit forms, or provide a platform using authorized means on which to cast the footing.

3.02 GRADE TOLERANCE

A. Immediately before placing subsequent layers of material, prepare the grading plane such that the grading plane:

1. Beneath structural approach slabs or the thickened portion of sleeper slabs do not extend above the grade established by the Engineer.
2. At any point is within 0.05 foot above the grade established by the Engineer if the material to be placed on the grading plane is paid by the cubic yard.
3. At any point is within 0.05 foot above the grade established by the Engineer if the material to be placed on the grading plane is below the bottom of the MSE wall leveling pad.

3.03 COMPACTION

A. Compact earthwork to not less than the following relative compaction percentages when tested in accordance with California Test 216 or California Test 231:

1. Structure backfill: 95 percent minimum.
2. Basement material beneath aggregate subbase: 95 percent minimum.
3. Backfill under concrete steps, flatwork, and slabs: 95 percent minimum.
4. Approved backfill material adjacent to and above pile caps: 95 percent minimum.
5. Structure backfill behind abutments and retaining walls: 95 percent minimum.

B. Moisture Control:

1. The moisture content of material to be compacted to at least 95 percent must be such that the specified relative compaction is attained and the embankment is in a firm and stable condition.
2. Do not compact material that contains excessive moisture until the material is dry enough.

C. Foundation Preparation:

1. You are responsible for preparing the foundation to receive material.
2. You may excavate and replace basement material to facilitate compaction. Before you replace the basement material, if ordered, compact a layer below the excavated material to a depth, width, and degree of compaction ordered. The ordered work is change order work.

3.04 STRUCTURE BACKFILL

A. Place structure backfill in uniform layers. Bring backfill up uniformly on all sides of structures. Backfill layers must be at most eight inches thick before compacting, except when compaction is performed by ponding or jetting. The thickness must be at most four feet when compaction is performed by ponding or jetting.

B. Do not use compaction equipment or methods that may cause excessive displacement or damage structures.

C. Do not place structure backfill until footings or other parts of the structure or facility are inspected by VTA and authorized for backfilling. Do not place backfill against the back of abutments, retaining walls, or outside walls of CIP concrete structures until the concrete has attained a compressive strength of at least 2,500 pounds per square inch or the concrete has been in place for 28 days.

D. Place backfill inside bridge wingwalls and abutments before railings on wingwalls are constructed.

E. Compaction by ponding and jetting may be authorized under the following conditions:

1. Backfill material is self-draining when compacted
2. Foundation materials will not soften or be damaged by water
3. Structures will not be damaged by hydrostatic pressure

F. Ponding and jetting of the upper four feet below finished grade is not allowed. Perform work without damaging the structure or embankment and such that water is not collected and confined. Supplement ponding and jetting with vibratory or other compaction equipment.

G. Compact structure backfill to a relative compaction of at least 95 percent.

H. At locations where ordered, place a compacted impervious backfill material for structure backfill placed within two feet of finished grade at abutments, abutment wingwalls, retaining walls, and other portions of structures

I. Any material you place outside the excavation pay limits material must comply with the material and compaction requirements of the adjacent structure backfill.

J. If imported borrow is shown on the Schedule of Quantities and Prices, you may use imported borrow as structure backfill if it complies with the specifications for structure backfill.

K. Material from structure excavation not used as structure backfill must be conditioned for reuse and properly stockpiled for later filling and backfilling operations, as specified for fill and backfill materials in Section 31 00 00, Earthwork, or disposed of as surplus material as specified in Section 31 00 00, Earthwork.

3.05 GEOCOMPOSITE DRAIN

A. Install the geocomposite drain with the drainage void and the filter fabric facing the embankment. The fabric facing the embankment side must overlap at least three inches at all joints and wrap around the exterior edges at least three inches beyond the exterior edge. If additional fabric is needed to provide overlap at joints and wraparound at edges, the added fabric must overlap at least six inches and be attached to the fabric on the geocomposite drain.

B. Place core material manufactured from impermeable plastic sheeting having nonconnecting corrugations with the corrugations approximately perpendicular to the drainage collection system.

C. If the fabric on the geocomposite drain is torn or punctured, replace the damaged section completely or repair it by placing a piece of fabric that is large enough to cover the damaged area and provide at least a six-inch overlap.

D. Treated Permeable Base: The following requirements are for treated permeable base to be placed around slotted plastic pipe at the bottom of geocomposite drains. For treated permeable base to be used directly under approach slabs, refer to Section 03 30 00, Cast-in-Place Concrete, for requirements

1. Treated permeable base to be placed around slotted plastic pipe at the bottom of geocomposite drains must be constructed in accordance with Section 29, “Treated Permeable Bases,” of the Caltrans Standard Specifications.
2. If asphalt treated permeable base is used, place the base material at a temperature of not less than 180 degrees Fahrenheit or more than 230 degrees Fahrenheit.

3.06 FIELD QUALITY CONTROL

A. The Independent Testing Agency must perform the following sampling, testing, and inspections:

1. Structure Backfill:

   a. Sieve Analysis: The Independent Testing Agency must perform sieve analysis at the materials site or stockpile, in accordance with California Test 202. At least one test must be performed for every 3,000 tons or 2,000 cubic yards, or fraction thereof of structure backfill material delivered, whichever is more frequent. A minimum of one test must be performed each day.
   b. Sand Equivalent: The Independent Testing Agency must test the sand equivalent value at the materials site or stockpile, in accordance with California Test 217. At least one test must be performed for every 3,000 tons or 2,000 cubic yards, or fraction thereof of structure backfill material delivered, whichever is more frequent. A minimum of one test must be performed each day.
   c. Relative Compaction: The Independent Testing Agency must test the relative compaction of structure backfill at each location where structure backfill is placed, in accordance with California Test 216 or 231. At least one test must be performed for every 2,000 square yards, or fraction thereof, and every eight inches of structure backfill thickness.
   d. Maximum Wet Density: The Independent Testing Agency must test the maximum wet density of structure backfill in accordance with California Test 216. At least one

test must be performed for every relative compaction test performed, as specified herein.

B. Notify the Engineer of the type of treated permeable base to be placed around slotted plastic pipe at the bottom of geocomposite drains at least 30 days before starting placement. After notification, do not change the type of permeable base without authorization.

END OF SECTION 31 23 43

SECTION 31 34 19

GEOSYNTHETIC SOIL REINFORCEMENT

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for placing geotextile soil reinforcement in roadway paving sections.

1.02 RELATED SECTIONS

A. Section 01 78 39, Project Record Documents

B. Section 32 12 16, Asphalt Paving

1.03 REFERENCED STANDARDS

A. State of California, Department of Transportation (Caltrans), Standard Specifications 2018:

1. Section 39, Asphalt Concrete
2. Section 92, Asphalt Binders
3. Section 96, Geosynthetics

1.04 SUBMITTALS

A. General: Refer to Special Conditions for submittal requirements and procedures.

B. Submit product data for each type of geosynthetic. Include test data in support of each proposed mix design.

C. 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.

1.05 MEASUREMENT AND PAYMENT

A. Measurement:

1. Paving Fabric shall be measured by the Square Yard.
2. Paving Mat shall be measured by the Square Yard.

B. Payment:

1. The contract price paid per Square Yard for Paving Fabric shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in placing paving fabric complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.
2. The contract price paid per Square Yard for Paving Mat shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in placing paving mat complete in place, as shown on the drawings, as

specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

A. Paving Fabric shall conform to the requirements of Section 96, Geosynthetics. of the Caltrans Standard Specifications.

B. Paving Mat shall conform to the requirements of Caltrans Standard Specifications Section 96, Geosynthetics.

C. Asphalt binder for tacking geosynthetics shall be PG 64-10 and conform to requirements of Section 92, Asphalt Binders, of the Caltrans Standard Specifications.

PART 3 – EXECUTION

A. Install geosyntethics per manufacturer specifications and in accordance with the requirements of Section 39, Asphalt Concrete, of the Caltrans Standard Specifications. Coordinate with requirements of Section 32 12 16, Asphalt Paving.

END OF SECTION 31 34 19

SECTION 31 62 00

DRIVEN PILES

PART 1 - GENERAL

1.01 SUMMARY

A. The scope of work outlined in this Section includes the following items of work, as detailed in these Technical Specifications, as shown on the plans or reasonably implied therefrom and is not limited to the following items:

1. Furnish and Drive Precast Prestressed Concrete Piling
2. Furnish and Drive 18” Steel Pipe Pile
3. Determination of Driven Pile Length
4. Indicator Piles and Load Test Piles
5. Axial Compression and Tension Load Testing
6. Dynamic Pile Testing

1.02 RELATED SECTIONS

A. Section 6.6.2, Submittal, of the Special Conditions

B. Section 7.43, Submittal of Shop Drawings, Product Data and Samples, of the General Conditions

C. Section 03 05 15, Portland Cement Concrete

D. Section 03 05 18, Prestressed Concrete

E. Section 03 20 00, Concrete Reinforcing

F. Section 03 30 00, Cast-in-Place Concrete

G. Section 03 41 00, Structural Precast Concrete

H. Section 05 05 60, Metal Welding

I. Section 05 12 35, Structural Steel

J. Section 05 17 00, Miscellaneous Metal

1.03 REFERENCED STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO) / State of California Department of Transportation (Caltrans):

1. AASHTO-CA BDS-6 — AASHTO LRFD Bridge Design Specifications, 2012 (6th Edition) with California Amendments, preface dated January 2014

B. ASTM International (ASTM):

1.	ASTM A36/A36M	Standard Specification for Carbon Structural Steel
2.	ASTM A252	Specification for Welded and Seamless Steel Pipe Piles
3.	ASTM A572/A572M	Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
4.	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
5.	ASTM A709/A709M	Standard Specification for Structural Steel for Bridges
6.	ASTM A760/A760M	Standard Specification for Corrugated Steel, Pipe, Metallic-Coated for Sewers and Drains
7.	ASTM A929/A929M	Standard Specification for Steel Sheet, Metallic Coated by the Hot-Dip Process for Corrugated Steel Pipe
8.	ASTM C881/C881M	Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
9.	ASTM D1143/D1143M	Standard Test Methods for Deep Foundations Under Static Axial Compressive Load (2007 (2013))
10.	ASTM D3689/D3689M	Standard Test Methods for Deep Foundations Under Static Axial Tensile Load (2007 (2013))
11.	ASTM D4945	Standard Test Method for High Strain Dynamic Testing of Deep Foundations (2012)

C. American Welding Society (AWS):

1.	ANSI/AWS D1.1/D1.1M	Structural Welding Code - Steel (2015)

D. State of California, Department of Transportation (Caltrans):

1.	California Test 226	Method of Test for Moisture Content of Soils and Aggregates by Oven Drying

E. State of California, Department of Transportation (Caltrans), Standard Specifications 2018:

1.	Section 49	Piling

1.04 REGULATORY REQUIREMENTS

A. Comply with applicable requirements of the California Code of Regulations, Title 24, Part 2, 2019 California Building Code, Chapters 18 and 18A, “Soils and Foundations.”

1.05 DEFINITIONS

A. Indicator Pile: An individual pile driven and monitored under dynamic load tests prior to pile production in order to evaluate the proposed pile driving equipment, determine pile length, and to observe pile behavior during and after initial driving.

B. Load Test Pile: An individual pile which is tested and monitored under static axial compression and tension load tests and under dynamic load tests.

C. Reaction Pile: An individual pile that provides the reaction load required to perform the load test on a load test pile. During this process the reaction pile can be subjected to either an axial compression load or an axial tension load.

D. Production Piles: Piles that are purchased and delivered for incorporation in the permanent structure.

E. Control Zone: Zone that has the same subsurface profile and engineering properties as a corresponding support location.

F. Nominal Driving Resistance: Sum of the nominal resistance required to resist the factored axial loads and the driving resistance from unsuitable or scourable penetrated soil layers that do not contribute to the design resistance.

G. Field Geotechnical Engineer: Professional engineer currently registered as a civil and geotechnical engineer in the State of California that will oversee pile driving operations, pile driving inspection, and the Contractor's quality control, and certify the pile installation prior to concrete placement.

H. Longitudinal weld length: The length of a continuous longitudinal weld.

I. Circumferential weld length: The length of a continuous weld around the circumference of the pipe pile.

J. Spiral weld length: The length of one full 360-degree spiral weld revolution around the circumference of the pipe pile.

K. The terms "steel shell" and "steel pipe" are used interchangeably

1.06 SUBMITTALS

A. General: Submittals for driven piles must be made in accordance with the provisions in Section 6.6.2, Submittal, of the Special Conditions, Section 7.43, Submittal of Shop Drawings, Product Data and Samples, of the General Conditions, and these Technical Specifications.

B. Shop Drawings: Submit two copies of Shop Drawings of pile types as follows:

1. Steel Pipe Piles: Show typical details of sizes, configuration, splices, tip construction, and welding of section connection, and class of concrete fill. Submit Shop Drawings for attaching handling devices that include locations, handling and fitting device details, and connection details.
2. Precast Prestressed Concrete Piles: Show pile dimensions, material type, prestressing methods, tendon arrangement and working stresses, any addition or rearrangement of reinforcement from that shown on the plans, class of concrete, lifting devices, curing methods, and pre-stressing methods. Include engineering calculations of working stresses. If splicing is required, submit details.
3. Load Test Piles: Show tension steel reinforcement and connections for uplift loads.
4. Shop Drawings must be submitted to VTA for review by VTA and the Structural Engineer of Record. Do not order materials, begin fabrication, or begin construction of work related to the submittal until the submittal has been reviewed and stamped by the Structural Engineer of Record with a Shop Drawing stamp marked "Reviewed" or "Make Corrections Noted" and returned to the Contractor by VTA.

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.
4. Shop Drawings must be submitted to VTA for review by VTA and the Structural Engineer of Record. Do not order materials, begin fabrication, or begin construction of work related to the

submittal until the submittal has been reviewed and stamped by the Structural Engineer of Record with a Shop Drawing stamp marked “Reviewed” or “Make Corrections Noted” and returned to the Contractor by VTA.

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, 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 must submit a certified copy of the pile driving record to VTA for record purposes.
2. For pile driving hammers with no way of visually observing the ram stroke, submit a printed readout as an informational submittal showing hammer energy during driving operations.

E. Pile Driving Equipment Shop Drawings:

1. Submit complete list of the equipment proposed for use, proposed arrangement of equipment during pile driving operations, and a description of the characteristics of each piece of driving equipment.

    a. Not used.
    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 must 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.
3. Submit Shop Drawings showing the methods and equipment proposed for loading load test piles.

F. Certificates:

1. Submit a certificate of compliance for steel pipe piles. The certificate of compliance must be signed by the plant’s Quality Control (QC) representative. The QC representative must be on record with Caltrans’s Office of Structural Materials. Include with the certificate of compliance:

    a. Statement that the materials and workmanship comply with these Technical Specifications and the required tests and inspections have been performed as described.
    b. Certified mill test reports for each heat number of steel used in pipe piles being furnished.
    c. Test reports for tensile, chemical, and any specified NDT. Test reports must be based on test samples taken from the base metal, steel, coil, or from the manufactured or fabricated piles.
    d. Calculated carbon equivalent. The carbon equivalent may be shown on the mill test report.

G. Driving System Submittal:

1. Before installing driven piles, submit a driving system submittal for each pile type for each of the support locations.
2. The driving system submittal must be sealed and signed by an engineer who is currently registered as a civil engineer in the State of California.
3. Submit a revised driving system submittal if the hammers change from those shown in the submittal.
4. For the driving system submittal, perform driveability studies as follows:

    a. Model the proposed driving system including hammers, cap blocks, and pile cushions based on a wave equation analysis.
    b. Use a computer program authorized by VTA.
    c. If the driveability analysis hammers indicate that open-ended pipe pile and steel shell penetration rates are less than 1 foot per 200 blows and the driving stresses exceed 80 percent of the yield strength of the pipe and steel shell, include assumptions for drilling through the center of the piles and shells.
    d. If a follower is used, include an analysis of the driving system with the follower and an analysis of the driving system without the follower.

5. Include in the driving system submittal the following:

    a. Results of the driveability analysis showing that the proposed driving systems will install piles to the specified tip elevation and nominal driving resistance shown. Driving systems must generate sufficient energy to drive the piles with compressive and tensile stresses not more than 90 percent of the yield strength of the pile as driven. Results must include the following:

        1) Pile compressive stress versus blows per foot.
        2) Pile tensile stress versus blows per foot.
        3) Nominal driving resistance versus blows per foot.

    b. Complete description of the following:

        1) Soil parameters used, including soil quake and damping coefficients, skin friction distribution, and ratio of shaft resistance to total resistance.
        2) Assumptions made regarding the formation of soil plugs, drilling through the center of open-ended steel shells, and the use of closure plates, shoes, and other tip treatment.

    c. List of the hammer operation parameters assumed in the analysis, including fuel settings, stroke limitations, and hammer efficiency.
    d. Copies of the test results from any previous pile load tests, dynamic monitoring, and all driving records used in the analyses.
    e. Completed Pile and Driving Data form included with these Technical Specifications.

6. Use the driving system and installation methods described in the approved driving system submittal for driving the indicator and load test piles. No change in the driving system from that submitted and approved will be allowed.
7. Approval of pile driving equipment must not relieve the Contractor of responsibility to drive piling free of damage to the specified tip elevation and the required individual pile capacity.
8. After the indicator pile program is complete, VTA will submit indicator pile driving logs and inspection reports to the Geotechnical Engineer of Record. The Geotechnical Engineer of Record will use this information to evaluate the length of piles required and the amount of drilling allowed. Revisions to the specified tip elevations, if necessary, and the length of drilling allowed, will be provided to the Contractor. The Contractor may make adjustments to the pile driving system prior to fabricating or driving the production piling. The revised

driving system must be submitted to VTA for review and acceptance, prior to using the revised driving system on production piling.

9. Driving system submittal must be submitted to VTA for review by VTA and the Geotechnical Engineer of Record. Do not order materials, begin fabrication, or begin construction of work related to the submittal until the submittal has been reviewed and stamped by the Geotechnical Engineer of Record with a Shop Drawing stamp marked "Reviewed" or "Make Corrections Noted" and returned to the Contractor by VTA.

H. Pile Driving Safety Plan: A detailed Pile Driving Safety Plan must be submitted to VTA and returned before performing any pile handling or pile installation operation at any location that is closer than the length of the pile being handled or installed to the edge of any area open to public traffic, railroad traffic, or public use. The pile driving safety plan must outline the measures that will be employed to provide for the safety of traffic, railroad, and the public. The pile driving safety plan must be stamped and signed by an engineer who is currently registered as a civil engineer in the State of California with expertise in Safety Engineering.

I. Survey During Pile Driving: The Contractor must be responsible to provide a continuing survey on a daily basis during pile driving. Utilize said survey data and assemble as-built plans showing the plan location and elevation of the butt of each pile with respect to the design location. This information must be provided to VTA on a daily basis.

J. Submit a cleanout method for open pipe piles partially filled with reinforced concrete, in accordance with the requirements specified herein.

1. Cleanout method submittal must be submitted to VTA for review by VTA and the Structural Engineer of Record. Do not order materials, begin fabrication, or begin construction of work related to the submittal until the submittal has been reviewed and stamped by the Structural Engineer of Record with a Shop Drawing stamp marked "Reviewed" or "Make Corrections Noted" and returned to the Contractor by VTA.

K. Pile Load Test Reports: Immediately following completion of load testing, submit two copies of the test report for each load test pile to VTA for record purposes. Include in the test report the data required by ASTM D1143/D1143M, and ASTM D3689/D3689M, as applicable.

1. The test report for each load test pile must be submitted to VTA for review by VTA and the Geotechnical Engineer of Record. Do not order materials, begin fabrication, or begin construction of work related to the submittal until the submittal has been reviewed and stamped by the Geotechnical Engineer of Record with a Shop Drawing stamp marked "Reviewed" or "Make Corrections Noted" and returned to the Contractor by VTA.

L. Dynamic Pile Test Reports: Immediately following completion of dynamic pile testing, the PDA Engineer must submit two copies of the test report for each indicator pile to VTA for record purposes. The test report will include the data required by ASTM D4945 and will be stamped and signed by the PDA Engineer.

M. Qualifications of Welders and Welding Procedures: Provide submittals in accordance with requirements of Section 05 05 60.

1.07 QUALITY CONTROL AND ASSURANCE

A. Codes and Standards: Comply with all Federal, State and local codes and safety regulations.

B. Inspection by VTA and Other Governing and Regulatory Authorities: Allow the Field Geotechnical Engineer and other governing and regulatory authorities to perform testing and inspection of materials and practices associated with construction within their jurisdiction on the Worksite during business hours for the purpose of ensuring that the Work is in compliance with the requirements of the Plans, these Technical Specifications, and other local, state and federal laws and regulations.

C. Contractor Quality Control:

1. Sampling, Testing and Inspection:

a. Hire an Independent Testing Agency to perform sampling, testing, and inspections in accordance with the provisions herein and Section 6.26, Quality Assurance and Quality Control Requirements, of the Special Provisions.
b. Hire a Pile Dynamic Analysis Engineer (PDA Engineer) to monitor and take dynamic measurements of piles under dynamic load tests and perform CAPWAP analyses of the dynamic pile testing data in accordance with the provisions herein.
c. Wherever it is specified herein that sampling, testing, or inspection must be performed by the Contractor, it must be understood to mean that said sampling, testing, or inspection must be performed by the Independent Testing Agency.
d. Cooperate with and notify VTA at least 48 hours in advance of sampling, tests and inspections, being performed by the Independent Testing Agency. VTA may elect to observe these procedures. Provide samples and facilities for inspection to VTA without extra charge if requested.
e. The Independent Testing Agency must collect samples of materials for testing in accordance with the provisions outlined herein and as directed by VTA.

2. Qualifications of the Independent Testing Agency: Refer to Section 6.26, Quality Assurance and Quality Control Requirements, of the Special Provisions.
3. Qualifications of the Pile Dynamic Analysis Engineer (PDA Engineer):

a. The PDA Engineer must have successfully completed PDA testing on four driven pile projects in the last six years with pile foundations similar to or greater than the pile diameters and lengths shown on the plans.
b. The PDA Engineer must be currently registered as a geotechnical engineer in the State of California.

4. Notify VTA and the Field Geotechnical Engineer at least 48 hours prior to performing any pile driving operations.
5. Allow the Field Geotechnical Engineer to have access to any pile driving or behavior information recorded by the Contractor.
6. Identify each lot of fabricated pipe piles to be shipped to the Worksite by assigning an individual lot number that identifies steel by heat number and tag in such a manner that each such lot can be accurately identified at the Worksite.
7. Remove all unidentified pipe piles received at the Worksite.
8. Provide VTA and the Field Geotechnical Engineer with every reasonable facility for properly observing and recording the behavior of each pile during the entire driving operation, including suitable means or devices that will indicate the penetration of the pile, from a reasonable and safe distance from the pile driver.

D. VTA Quality Control and Assurance:

1. VTA will monitor the implementation of the Contractor's quality control programs through observation, inspection, sampling and testing in accordance with Section 6.26, Quality Assurance and Quality Control Requirements, of the Special Provisions.
2. Failure of VTA to detect work or material which is defective or contrary to these Technical Specifications must not prevent later rejection when such work or material is discovered, nor must it obligate VTA for final acceptance.

3. VTA will inspect precast, prestressed concrete piles at the fabrication site. Notify VTA at least 10 days before fabricating any piles. Materials to be used must be available to VTA for testing.
4. VTA will select a Field Geotechnical Engineer to oversee pile driving operations, provide pile inspection, and monitor the implementation of the Contractor’s quality control programs through observation, inspection, and sampling and testing in accordance with Section 6.26, Quality Assurance and Quality Control Requirements, of the Special Provisions.
5. Qualifications of the Field Geotechnical Engineer:

    a. The Field Geotechnical Engineer will be currently registered as a geotechnical engineer in the State of California.

6. The Field Geotechnical Engineer will certify the final pile installation prior to placement of any concrete. After the steel pipe pile is driven and before placing reinforcement and concrete, the Field Geotechnical Engineer examines the steel pipe pile for collapse or a reduced diameter at any point. The Field Geotechnical Engineer rejects any steel pipe pile that is improperly driven, broken, or shows partial collapse to an extent as to materially decrease its nominal resistance.
7. The VTA will monitor the Contractor’s pile welding operations for compliance with the Contractor’s Welding Quality Control Plan, as specified in Section 05 05 60, Metal Welding.

E. Installation Tolerances:

1. Maximum deviation of driven pile from vertical plumb: 1/4 inch per foot of pile length.
2. Maximum deviation of pile center at cutoff from location shown on plans: 6 inches.
3. Piles must not be closer than four inches from any edge of the pile cap.
4. Maximum deviation of driven pile cutoff elevation: 1 inch.

F. Piles delivered to the Worksite that are cracked, bowed, chipped, under size, or that break under driving stresses must be rejected. Remove such piles from the Worksite and replace with sound piles.

G. Welding and welders' qualifications must conform to the applicable requirements of Section 05 05 60, Metal Welding.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Except for piles to be used for the indicator and load test pile program, any materials ordered or delivered to the Worksite prior to verification of the final production pile specified tip elevations will be at the Contractor's risk.

B. After the production pile specified tip elevations are provided to the Contractor by VTA, deliver materials to the Worksite in such quantities and at such times as to ensure the continuity of pile driving operations with the project schedule.

C. Lift and support piles at approved points. Handle in a manner to avoid excessive bending stresses or other damage.

D. When handling or transporting precast, prestressed concrete piles, provide slings or other equipment to avoid bending the pile or cracking the concrete. Replace piles materially damaged in handling or during driving.

E. Delivered materials which, in the opinion of VTA or Independent Testing Agency, are damaged or otherwise not suitable for installation must be removed from the Worksite and replaced with acceptable materials.

1.09 SITE AND FOUNDATION CONDITIONS

A. Foundation Investigations:

1. The foundation investigations and other reports of the soil and subsurface conditions at the Worksite are available. The Contractor must read and be thoroughly familiar with the following available investigations and reports prior to bidding:

   a. "Eastridge to BART Regional Connector Capitol Expressway Light Rail Project 95% Design Phase Geotechnical Report," dated June 29, 2020, by Parikh Consultants, Inc.

2. The data presented in the reports are not intended as representations or warranties of the continuity of such conditions and are made available only for convenience of the Contractor. Soil conditions between borings may vary in an irregular manner. It is expressly understood that the VTA, the Geotechnical Engineer of Record, and the Structural Engineer of Record will not assume any responsibility for such variations that may exist, nor for any interpretations, deductions, or conclusions that the Contractor may make from information made available by VTA.
3. The Contractor must not be relieved of liability under the Contract for any loss sustained as a result of any variance between conditions indicated or conclusions reached from the foundation investigations and the actual conditions encountered during the course of the work.

B. Examination of Worksite: The Contractor may examine the Worksite and make his own subsurface explorations to evaluate the driving conditions.

C. Preliminary Inspection: Before any piles are driven, examine all excavations, shoring, and bracing to confirm their adequacy before pile driving operations begin. If the excavations, shoring, and bracing are inadequate, pile driving must not proceed until corrective action has been taken.

D. Location of Pipes, Sewers, Utilities and other Facilities: Do not commence work until the location and extent of all existing pipes, sewers, utilities and other facilities are determined. Do not commence pile installation work until all facilities designated for removal have been excavated in their entirety and the resulting excavations properly backfilled.

E. Accept the Worksite in its present condition.

F. Corrosive Soils:

1. Piles at Capitol Aerial Guideway Bent 40 through Bent 55 are in a corrosive environment and must conform to the requirements specified herein for piles placed in a corrosive environment.

G. Difficult Pile Installation:

1. Expect difficult pile installation due to the conditions shown in the following table:

Pile Location		Conditions
Structure	Support Location	
Capitol Aerial Guideway, Story Station Pedestrian Overcrossing and Access Structures	All bent locations along Capitol Expressway	Traffic control, staged construction, noise control, potential high ground water
Capitol Aerial Guideway	Bent 10	Proximity to existing water line. Undersized predrilling is required. Proximity to existing PG&E gas line.
Capitol Aerial Guideway	Bents 11 through 13	Proximity to existing underground utilities
Capitol Aerial Guideway	Bent 14	Proximity to existing water line. Undersized predrilling is required
Capitol Aerial Guideway	Bent 17	Proximity to existing underground utilities
Capitol Aerial Guideway	Bents 32 through 35	Potential dense sand layer
Capitol Aerial Guideway	Bent 44	Potential dense sand layer
Capitol Aerial Guideway	Bent 45	Potential dense sand layer
Capitol Aerial Guideway	Bent 47	Proximity to existing underground utilities
Capitol Aerial Guideway	Bent 56	Proximity to existing underground utilities
Capitol Aerial Guideway	Bent 57	Proximity to overhead power lines
Capitol Aerial Guideway	Bent 58	Bent under overhead power lines
Capitol Aerial Guideway	Bent 59	Proximity to overhead power lines
Capitol Aerial Guideway	Bent 62	Proximity to existing underground utilities
Capitol Aerial Guideway	Bents 64 through 66	Potential dense sand layer
Capitol Aerial Guideway	Bent 74	Proximity to existing underground utilities
Capitol Aerial Guideway	Bent 75	Proximity to existing underground utilities
South Approach Walls	SB Station 1080+05 to Station 1081+96	Traffic control, staged construction, noise control, potential high ground water

1.10 MEASUREMENT AND PAYMENT

A. Measurement:

1. Furnish Precast Prestressed Concrete Piling of the various sizes shown in the Schedule of Quantities and Prices must be measured by the linear foot.

   a. The payment quantity for Furnish Precast Prestressed Concrete Piling is the length measured along the longest side of the pile from the specified tip elevation shown to the plane of pile cutoff, except for piles monitored under dynamic load tests.

   b. For piles monitored under dynamic load tests, including indicator piles and load test piles, the payment quantity for Furnish Precast Prestressed Concrete Piling is the length measured along the longest side of the pile from the specified tip elevation shown to the bottom of footing elevation shown, plus an additional length of fifteen feet.

2. Furnish 18" Steel Pipe Piling must be measured by the linear foot.

    a. The payment quantity for Furnish 18" Steel Pipe Piling is the length measured along the longest side of the pile from the specified tip elevation shown to the plane of pile cutoff, except for piles monitored under dynamic load tests.

3. Drive Precast Prestressed Concrete Pile of the various sizes shown in the Schedule of Quantities and Prices must be measured by the individual unit (each), per each pile driven and accepted, regardless of pile length driven, tip elevation, or penetration.
4. Drive 18" Steel Pipe Pile must be measured by the individual unit (each), per each pile driven and accepted, regardless of pile length driven, tip elevation, or penetration.

B. Payment:

1. The contract price paid per linear foot for Furnish Precast Prestressed Concrete Piling of the various types listed in the Schedule of Quantities and Prices must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in fabricating and delivering precast prestressed concrete piling to the Worksite ready to incorporate into the work complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefor.
2. The contract price paid per linear foot for Furnish 18" Steel Pipe Piling must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in fabricating and delivering steel pipe piling to the Worksite ready to incorporate into the work complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefor.
3. The contract price paid per individual unit (each) for Drive Precast Prestressed Concrete Pile of the various types listed in the Schedule of Quantities and Prices must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in driving precast prestressed concrete piling into the final position in the work complete in place to the required nominal resistance and penetration, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefor.
4. The contract price paid per individual unit (each) for Drive 18" Precast Prestressed Concrete Pile must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in driving steel pipe piling into the final position in the work complete in place to the required nominal resistance and penetration, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefor.

C. Full compensation for furnishing piles to the Worksite, furnishing concrete, splicing piles, furnishing and installing pile anchors and lugs, and furnishing all reinforcement for piles with a diameter of less than 24 inches, including reinforcement required to extend beyond the pile as shown on the drawings, must be considered as included in the bid items for Furnish Precast Prestressed Concrete Piling and Furnish 18" Steel Pipe Piling and no additional compensation will be allowed therefor.

D. Full compensation for driving and cutting the piles off at the elevations shown, drilling holes or predrilling holes through embankments, and disposing of material resulting from drilling holes or predrilling holes must be considered as included in the bid item for Drive Precast Prestressed Concrete Pile of the various sizes listed in the Schedule of Quantities and Prices and no additional compensation will be allowed therefor.

E. Full compensation for driving and cutting the piles off at the elevations shown, furnishing special driving tips or heavier sections of steel piles, drilling holes or predrilling holes through embankments, and disposing of material resulting from drilling holes or predrilling holes must be considered as included in the bid item for Drive 18” Steel Pipe Pile and no additional compensation will be allowed therefor.

F. Full compensation for cleaning out and disposing of material from steel pipe piles, placing seal course concrete in steel pipe piles, dewatering steel pipe piles, and placing concrete and reinforcement, including reinforcement required to extend beyond the pile as shown on the drawings, must be considered as included in the bid items for Drive 18” Steel Pipe Pile and no additional compensation will be allowed therefor.

G. Full compensation for driven pile cutoffs and removal of cutoffs from the Worksite must be considered as included in the bid items for Drive Precast Prestressed Concrete Pile of the various types and sizes listed in the Schedule of Quantities and Prices and Drive 18” Steel Pipe Pile and no additional compensation will be allowed therefor.

H. Full compensation for dynamic pile testing and axial compression and tension load testing, including designing, furnishing, and installing reaction piles and the associated load test set up, must be considered as included in the bid item for Drive Precast Prestressed Concrete Pile of the various types and sizes listed in the Schedule of Quantities and Prices and no additional compensation will be allowed therefor.

I. Piles driven outside of a production pile location for your convenience will not be measured separately for payment, and no additional compensation will be allowed therefor.

J. Reaction piles installed at locations other than production pile locations for your convenience will not be measured separately for payment, and no additional compensation will be allowed therefor.

K. Rejected piles will not be measured separately for payment, and no additional compensation will be allowed therefor.

L. Extracted rejected piles must become your property and must be removed from the Worksite, and no additional compensation will be allowed therefor.

M. Furnishing and driving substitute piles, when required for remediation of installed driven piles exceeding specified tolerances, will not be measured separately for payment, and no additional compensation will be allowed therefor.

N. If you are ordered to place additional lugs on steel piles, the additional work involved in driving piles due to these additional lugs will not be measured separately for payment, and no additional compensation will be allowed therefor.

PART 2 - PRODUCTS

2.01 PILES

A. Steel Pipe Piles:

1. Steel Pipe:

   a. Steel pipe piles must consist of diameter and shell thickness indicated.
   b. Fabricate steel pipe piles at a plant currently on the Caltrans Authorized Facility Audit List. The Caltrans Authorized Facility Audit List can be found at the following

website:
https://mets.dot.ca.gov/afl/AuditedFacilitiesList.php?afl=4

c. Steel pipe piles must comply with one of the following:

1) API 5L, minimum Grade X52, PSL1, and must be:

a) Manufactured, welded, tested, and inspected at a plant licensed to apply the API monogram, except hydrostatic testing, flattening tests, and the API monogram are not required.
b) Marked “Caltrans Class R - API” on each length of steel pipe.

2) ASTM A252, Grade 3, and the following:

a) Arc welding processes must comply with AWS D1.1/D1.1M.
b) Groove welds using submerged arc welding from both sides without backgouging require a procedure qualification record witnessed by VTA.
c) Underfill is not allowed.
d) For electric resistance welded pipe, remove the outer diameter flash to a maximum of 1/32 inch.
e) Weld reinforcement must not exceed 1/8 inch.
f) Weighing of individual pipe is not required as specified in ASTM A252.
g) Each length of pipe must be marked “Caltrans Class R - A 252”.

d. The carbon equivalent of steel in steel pipe piles must not exceed 0.47 percent. Use the following formula to calculate the carbon equivalent:
$CE = C + (Mn + Si)/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15$
where CE = carbon equivalent, percent

e. Sulfur content of steel in steel pipe piles must not exceed 0.05 percent.

f. Dimensional tolerances of steel pipe piles must comply with the following:

1) Outside diameter: Plus or minus 0.75 percent of the outside diameter shown.
2) Wall thickness: Minus 5 to plus 10 percent of the nominal wall thickness shown.
3) Straightness: Plus or minus 1.0 percent over the length of the pipe.

g. Steel pipe piles must be sufficiently watertight to exclude water during concrete placement.

h. Steel plates and welding must conform to applicable requirements of Section 05 12 35 Structural Steel, Section 05 05 60, Metal Welding, and this Technical Specification Section.

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.

a. Unless otherwise shown on the plans, concrete must have a minimum 28-day compressive strength of 5,000 pounds per square inch.
b. Prepare separate mix designs for each class of concrete.
c. Slump and Penetration: Refer to Section 03 05 15, Portland Cement Concrete, for requirements.
d. Concrete Placed Under Slurry:

1) Slump: Refer to Section 03 05 15, Portland Cement Concrete, for requirements.
2) Concrete placed under slurry must contain at least 675 pounds of cementitious material per cubic yard and be proportioned to prevent excessive bleed water and segregation.
3) For concrete placed under slurry, the combined aggregate gradation must comply with the 1/2-inch maximum gradation or the 3/8-inch maximum gradation specified in Section 03 05 15, Portland Cement Concrete.

e. Prequalify the concrete under Section 03 05 15, Portland Cement Concrete.
f. The combined aggregate gradation must comply with the 1-inch, 1/2-inch, or 3/8-inch maximum gradation specified in Section 03 05 15, Portland Cement Concrete.

B. Precast, Prestressed Concrete Piles: Precast, prestressed concrete piles, of sizes and requirements indicated.

1. Concrete Reinforcement: Conform to applicable requirements of Section 03 20 00, Concrete Reinforcing, of grades and sizes indicated.
2. Concrete: Conform to applicable requirements of Section 03 05 18, Prestressed Concrete, Section 03 41 00, Structural Precast Concrete, and Section 03 05 15, Portland Cement Concrete.

a. Unless otherwise shown on the plans, concrete must have a minimum 28-day compressive strength of 7,000 pounds per square inch.
b. Concrete for piles in a corrosive environment must meet the requirements for concrete in corrosive environments, as specified in Section 03 05 15, Portland Cement Concrete.

3. Prestressing Steel: Conform to applicable requirements of Section 03 05 18, Prestressed Concrete.
4. Threaded Inserts: Threaded inserts and other fittings must comply with Section 05 17 00, Miscellaneous Metal.
5. Epoxy Adhesive: Epoxy adhesive for filling holes in precast prestressed concrete piles to be placed in a corrosive environment must be a low-viscosity epoxy formulated primarily for use in making high-strength epoxy concrete and epoxy mortar and pressure grouting cracks in concrete.

a. The epoxy must comply with ASTM C881/C881M, Type I, Grade 1, Class B or C.

1) Use Class B whenever the surface temperature is from 40 to 60 degrees Fahrenheit. Use Class C whenever the surface temperature is above 60 degrees Fahrenheit.
2) Thoroughly mix the components before adding aggregate. The mix proportions must be one part epoxy to four parts aggregate by volume. Aggregate must be clean and have a moisture content of not more than 0.50 percent when tested under California Test 226.

2.02 WELDING OF STEEL PIPE PILES

A. Welding of steel pipe piles must conform to applicable requirements of Section 05 12 35, Structural Steel, and Section 05 05 60, Metal Welding and the requirements specified herein.

B. Seams in steel pipe piles must conform to the requirements of AWS D1.1/D1.1M and any amendments listed herein, and must be complete joint penetration welds. Underfill is not allowed.

C. For welding and prequalifying base metal under Table 3.1 of AWS D1.1/D1.1M, treat steel pipe piles complying with ASTM A252 as either ASTM A572/572M, Grade 50, or ASTM A709/709M, Grade 50.

D. For groove welds using submerged arc welding from both sides without backgouging, qualify the WPS under Table 4.5 of AWS D1.1/D1.1M. Groove welds using submerged arc welding from both sides without backgouging require a procedure qualification record witnessed by the Engineer.

E. Butt welded seams subsequently formed, including skelp end welds, must be 100 percent ultrasonically tested in the final formed and welded condition. The acceptance criteria for ultrasonic testing (UT) must comply with one of the following:

1. API 5L for API-licensed facilities
2. AWS D1.1/D1.1M for cyclically loaded nontubular connections for welds subject to tensile stress

F. Except for tack welding, do not use gas metal arc welding for welding of steel pipe piles. If gas metal arc welding is used for tack welding, do not deposit filler metal by short circuiting transfer.

G. For electric resistance welded pipe, remove the outer diameter flash to a maximum of 1/32 inch.

H. Weld reinforcement must not exceed 1/8 inch.

I. Circumferential Welds:

1. Welds must comply with AWS D1.1/D1.1M.
2. Circumferential welds must be complete penetration joint welds.
3. Locate circumferential welds at least 12 inches away from a skelp end weld.
4. Backing rings must comply with the following:

    a. Minimum thickness of the backing ring must be 1/4 inch and the backing ring must be continuous.
    b. Splices in the backing ring must be made by CJP welds. These welds must be completed and inspected, including performing any required NDT, before final insertion into a pipe end.
    c. Attach backing rings to pipe ends using the minimum size and spacing of tack welds that will securely hold the backing ring in place. Tack weld in the root area of the weld splice. Remove and replace cracked tack welds before subsequent weld passes.
    d. Gap between the backing ring and the steel pipe wall must not be greater than 5/64 inch. You may offset 1 localized portion of the backing ring fit-up by a gap equal to or less than 1/4 inch if the localized portion is (1) equal to or less than 20 percent of the outside circumference of the pipe, (2) first seal welded using shielded metal arc E7016 or E7018 electrodes, and (3) marked such that it can be referenced during any required NDT.
    e. Backing rings must have enough width such that the backing ring does not interfere with the interpretation of the NDT.

5. If splicing steel pipe piles using a circumferential weld, the piles must comply with the fit-up requirements of clause 9.24.1 of AWS D1.1/D1.1M.

2.03 PILE FABRICATION

A. Steel Pipe Piles:

1. Except for steel pipe piles marked with the API monogram, mark each length of the steel pipe pile as follows:

    a. Name and location of the piling manufacturer
    b. Heat number
    c. Welding process
    d. Outer diameter, nominal wall thickness, minimum wall thickness, and length
    e. Year piling was produced
    f. Markings specified for each class of steel pipe piling

2. Only Caltrans-authorized audited facilities are authorized to mark piling.

B. Precast Prestressed Concrete Piles:

1. Place concrete for precast prestressed concrete piles in smooth, mortar-tight forms. Support the forms to prevent appreciable deformation or settlement during placing or curing.
2. Finish unformed surfaces to a smooth surface.
3. Piles in a corrosive environment must be steam cured in accordance with Section 03 41 00, Structural Precast Concrete, or cured by the water method in accordance with Section 03 35 00, Concrete Finishing.

    a. If piles in a corrosive environment are steam cured, do one of the following:

        1) Keep the piles continuously wet for at least three days. The three days includes the holding and steam curing periods.
        2) Apply curing compound in accordance with Section 03 35 00, Concrete Finishing, immediately after steam curing.

    b. If piles to be placed in a corrosive environment are water cured, the piles must be kept continuously wet by the application of water as specified in Section 03 35 00, Concrete Finishing.

4. When removed from the form, the pile must:

    a. Have true, smooth, even surfaces, free from honeycombs and voids
    b. Be straight such that a line stretched from butt to tip on any pile face is not more than one inch from the face of the pile at any point

5. Except for precast prestressed concrete piles to be placed in a corrosive environment, remove lifting anchors and fill holes in accordance with the requirements for "Ordinary Surface Finish," as specified in Section 03 35 00, Concrete Finishing.
6. For precast prestressed concrete piles to be placed in a corrosive environment, remove lifting anchors to a depth of at least one inch below the concrete surface. Fill holes with epoxy adhesive before delivering piles to the Worksite.
7. If using pile anchor dowels, anchor the dowels in cast or drilled holes in the concrete pile with neat cement paste. The diameter of the holes must be the minimum consistent with placing the neat cement paste and dowel.
8. Use methods for drilling holes that do not damage the concrete, reinforcement, or prestressing steel.
9. The drilled hole must be free of dust and other deleterious material when placing the neat cement paste. Neat cement paste and dowel must completely fill the drilled hole. The dowels must be left undisturbed until the paste has hardened.

2.04 SOURCE QUALITY ASSURANCE

A. VTA Quality Assurance:

1. VTA will inspect precast, prestressed concrete piles at the fabrication site. Notify VTA at least 10 days before fabricating any piles. Materials to be used must be available to VTA for testing.

PART 3 - EXECUTION

3.01 PILE TYPES

A. Piles must be friction piles or combined friction and end-bearing piles as indicated. Piles must be driven to the required penetration, as indicated.

3.02 DETERMINATION OF LENGTH

A. Piles must be of such lengths as required to develop the specified capacity, to attain the specified tip elevation shown, and extend into the pile cap or footing.

B. The plans indicate the required type of piling, the required compression and tension capacity, the minimum penetration, and the estimated pile tip elevation.

C. Lengths of production piles and pile tip elevations will be provided to the Contractor by VTA based on the review of the indicator pile and load test pile driving records and pile load test reports by the Geotechnical Engineer of Record.

D. You may conduct additional foundation investigation, including installing and axial load testing of additional nonproduction indicator piling, in accordance with Article 3.03 herein. Locations of additional foundation testing must be authorized by VTA. Notify VTA at least five work days before starting additional foundation testing.

1. Complete additional foundation investigation before requesting revised specified pile tip elevations or revisions to the described installation methods.

E. The following revisions are not authorized:

1. Specified installation methods if settlement or lateral loads control the design tip elevation.
2. Specified pile tip elevation above the design tip elevation shown for settlement or lateral loads.
3. Specified pile tip elevation if the tip elevation is controlled by liquefaction or scour.

F. The pile structural capacity design is based on the nominal resistance as defined in Article 1.3.2.1 and Section 10 of AASHTO-CA BDS-6.

3.03 INDICATOR PILES AND LOAD TEST PILES

A. Based upon available subsurface information and the Geotechnical Report, the Contractor must order and drive the indicator piles and load test piles. Compression and tension capacities of the load test piles must be determined by methods hereinafter specified. In general, the specified length of indicator piles and load test piles must be the length measured along the longest side of the pile from the specified tip elevation shown to the bottom of footing elevation shown, plus an additional length of fifteen feet minimum.

1. The indicator and load test pile program must be performed in advance of fabricating production piles in order to accomplish the following:

    a. Establish production pile lengths.
    b. Determine pile driveability and the depth of drilling to be allowed or required.
    c. Confirm the compatibility of the pile hammer with the pile and soil conditions.
    d. Determine the behavior of pile during driving, included driving stresses.
    e. Establish pile driving criteria for use by the Engineer in evaluating the pile capacity.

B. Locations for the indicator piles and load test piles must be as follows:

1. Drive indicator piles at production pile locations noted herein. Indicator piles must be driven at a central location within the pile cap selected by the Field Geotechnical Engineer at the following locations:

Structure	Bent Number	Total Number of Indicator Piles per Bent
Capitol Aerial Guideway	Bent 6W	1
Capitol Aerial Guideway	Bent 10	1
Capitol Aerial Guideway	Bent 12	1
Capitol Aerial Guideway	Bent 14	1
Capitol Aerial Guideway	Bent 16	1
Capitol Aerial Guideway	Bent 18	1
Capitol Aerial Guideway	Bent 20	1
Capitol Aerial Guideway	Bent 22	1
Capitol Aerial Guideway	Bent 26	1
Capitol Aerial Guideway	Bent 28	1
Capitol Aerial Guideway	Bent 30	1
Capitol Aerial Guideway	Bent 32	1
Capitol Aerial Guideway	Bent 34	1
Capitol Aerial Guideway	Bent 36	1
Capitol Aerial Guideway	Bent 38	1
Capitol Aerial Guideway	Bent 42	1
Capitol Aerial Guideway	Bent 44	1
Capitol Aerial Guideway	Bent 46	1
Capitol Aerial Guideway	Bent 48	1
Capitol Aerial Guideway	Bent 50	1
Capitol Aerial Guideway	Bent 52	1
Capitol Aerial Guideway	Bent 54	1
Capitol Aerial Guideway	Bent 56	1
Capitol Aerial Guideway	Bent 61	1
Capitol Aerial Guideway	Bent 63	1
Capitol Aerial Guideway	Bent 66	1
Capitol Aerial Guideway	Bent 68	1
Capitol Aerial Guideway	Bent 70	1
Capitol Aerial Guideway	Bent 72	1
Capitol Aerial Guideway	Bent 74	1
Capitol Aerial Guideway	Abutment 76	1

2. Load test piles must be located as noted herein. Load test piles must be driven within twenty feet from production pile locations, at the following bent locations:

Structure	Location	Total Number of Load Test Piles per Location
Capitol Aerial Guideway	Bent 8	1
Capitol Aerial Guideway	Bent 24	1
Capitol Aerial Guideway	Bent 40	1
Capitol Aerial Guideway	Bent 59	1

a. If additional load test piles are required, they must be driven at locations selected by the Field Geotechnical Engineer.

C. Driving equipment used for driving indicator and load test piles must be identical to that what the Contractor proposes to use for the driving of production piles.

D. Contractor may either install indicator piles and load test piles from original ground or excavate to the bottom of footing elevation before installing indicator piles and load test piles.

E. Indicator piles and load test piles must be driven to a hammer blow count established by the Contractor's driving system submittal at the estimated tip elevations. Piles that do not attain the hammer blow count specified above, at a depth of one foot above the estimated tip elevation indicated, must be allowed to "set up" for a minimum of two days before being re-driven. In areas where indicator piles are predominately supported in clay or silt, a longer "set up" time may be ordered by the Field Geotechnical Engineer. A cold hammer must not be used for re-drive.

F. If the specified hammer blow count is not attained on re-driving, the Field Geotechnical 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 must be driven to the planned grade and, when not having the required capacity, a new indicator pile must be driven and allowed to "set up" for a longer time before being re-driven.

G. A record of driving of indicator and load test piles will be prepared by the Field Geotechnical Engineer that will include the number of hammer blows per foot for the entire driven length, the as-driven length of the pile, cutoff elevation, penetration in ground, and any other pertinent information. If re-drive is necessary, the Field Geotechnical Engineer will record the number of hammer blows per inch of pile movement for the first foot of re-drive. The Contractor must not order production piles until indicator and load test pile data has been reviewed and pile order lengths are authorized by VTA in writing.

H. VTA 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.

I. All indicator piles must be monitored under dynamic load tests by the PDA Engineer as specified in Article 3.06, "Dynamic Pile Testing," herein. Indicator piles accepted by the Geotechnical Engineer of Record will be incorporated into the final guideway foundations.

J. Remove rejected indicator piling as specified for removing portions of bridges.

K. All load test piles must be monitored under dynamic load tests by the PDA Engineer as specified in Article 3.06, "Dynamic Pile Testing," herein prior to axial load testing. Contractor must perform axial compression and tension load test as specified in Article 3.04, "Axial Compression and Tension Load Tests," herein. Load test piles must not be incorporated into the final guideway foundations.

3.04 AXIAL COMPRESSION AND TENSION LOAD TESTS

A. The load test piles must be located as specified herein. The Contractor must use four reaction piles for the tests. The reaction pile must be production piles of the same type and kind as shown on the plans, or alternatively, the Contractor may use an alternative reaction pile system at locations approved by the Field Geotechnical Engineer.

1. Construct load test piles as shown on the plans.
2. Install load test piles vertically.
3. Load test requirements including design loads must be as indicated in these Technical Specifications or as shown on the plans.

B. 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 must be re-driven to the previous elevation.

C. Conduct compression load test prior to conducting tension load test on the same load test pile.

D. After all testing is complete, cut load test piles three feet below any structure to be installed above. Backfill and compact holes.

E. Compression Load Tests: Tests must be performed in accordance with ASTM D1143/D1143M. Method of load test must follow "Procedure A: Quick Test" as specified in ASTM D1143/D1143M, Section 8.1.2.

1. Commence loading of load test piles not sooner than 72 hours after installation of precast, prestressed concrete piles.
2. The maximum test load must be at least the nominal driving resistance shown on the plans for the specific support location. Apply the load in increments equal to 5 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 Field Geotechnical Engineer.
3. Remove the test load in 5 to 10 approximately equal decrements, with a constant time interval between decrements of 5 minutes.
4. Measure the settlement and rebound of the load test pile to the nearest 0.01 inch.
5. The pile must sustain the compression test load applied with no more than 1/2 inch total vertical movement at the top of the pile measured relative to the top of the pile before the start of compression load testing.

F. Tension Load Tests: Tests must be performed in accordance with ASTM D3689/D3689M. Method of load test must follow "Procedure A: Quick Test" as specified in ASTM D3689/D3689M, Section 8.1.2. Do not use the loading apparatus described as "Tensile Load Applied by Hydraulic Jack(s) Acting Upward at One End of Test Beam(s)."

1. The maximum test load must be at least the nominal tension resistance shown on the plans for the specific support location. Apply the load in increments equal to five percent of the maximum test load, with a constant time interval between increments of five minutes. Maintain the maximum test load for not less than 15 minutes, unless the pile has failed as determined by the Field Geotechnical Engineer.
2. Remove the test load in 5 to 10 approximately equal decrements, with a constant time interval between decrements of five minutes.
3. The pile must sustain the tension test load applied with no more than 1/2 inch total vertical movement at the top of the pile measured relative to the top of the pile before the start of tension load testing.

G. Compression load tested piles that are damaged or have moved vertically more than 1/2 inch relative to the top of the pile before the start of compression load testing must not be used for tension load testing. In the event that the same pile cannot be used for both compression and tension load tests, additional load test piles will be required.

H. The Engineer may require the Contractor to make additional load tests that are not indicated, in the event that the behavior of the load test pile or any other pile shows any peculiarity, erratic action, or otherwise causes suspicion as to the reliability of the pile capacity.

I. Immediately following completion of load testing, submit two copies of the test report for each load test pile in accordance with Article 1.06K herein.

3.05 NOT USED

3.06 DYNAMIC PILE TESTING

A. Dynamic pile testing must be performed in accordance with ASTM D4945.

B. Dynamic measurements must be taken by the PDA Engineer during the initial driving and re-driving of the indicator piles and load test piles using dynamic pile analyzer monitoring instruments furnished by the Contractor. All indicator piles and load test piles must be dynamically monitored as specified herein.

C. Prior to placement in the leads, the Contractor must make each designated pile available to the PDA Engineer for taking wave speed measurements and for pre-drilling the required instrument attachment holes. When wave speed measurements are made, the piling must be in a horizontal position and not in contact with other piling.

D. The Contractor must furnish the equipment, materials, and labor necessary for drilling holes in the piles for mounting the instruments. Instruments must be attached near the head of the pile with expansion-type bolts.

E. The Contractor must provide safe access to the pile for the PDA Engineer to drill the pile and attach instruments after the pile is placed in the leads.

F. The Contractor must furnish electric power that is compatible for the dynamic test equipment at locations where the work will be performed. Field generators used as the power source must be equipped with meters for monitoring voltage and frequency levels.

G. The Contractor must drive the indicator pile to the design tip elevation or other depth specified by the Field Geotechnical Engineer. The stresses in the piles must be monitored by the PDA Engineer during driving with the dynamic test equipment to ensure that the values determined do not exceed the allowable values. If necessary, the Contractor must 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 must immediately realign the driving system.

H. The Contractor must wait up to a minimum of five days and, after the instruments are re-attached, re-drive the indicator or load test pile to allow for dynamic load monitoring to be performed by the PDA Engineer. A cold hammer must not be used for the re-drive. The minimum amount of penetration required during re-drive must be six inches, or the maximum total number of hammer blows required must be 50, whichever occurs first. After re-driving, the PDA Engineer must perform CAPWAP analyses of the dynamic pile testing data and submit the CAPWAP analyses to the Geotechnical Engineer of Record for acceptance.

I. The Contractor must be responsible for any damage to the cables and instruments caused by the Contractor’s operations.

3.07 INSTALLATION OF PILES

A. Pile Types: Provide piles of the type indicated and of the length and configuration as determined by the Geotechnical Engineer of Record in accordance with the Final Geotechnical Report and data from the indicator and load test piles. Piles must be of such lengths as required to develop the specified capacity, to attain the specified tip elevation shown, and extend into the pile cap or footing.

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 is not permitted unless specifically approved in writing by VTA for the location.

C. Predrilled Holes:

1. For all support locations with driven piles, except as noted otherwise herein, do not use drilling to attain the specified tip elevation shown.
2. Before driving piles, drill holes with a diameter not greater than the least dimension of the pile to attain the specified tip elevation shown for driven piles at the locations and to the bottom of hole elevations shown in the following table:

Structure	Bent Number	Bottom of Hole Elevation
Capitol Aerial Guideway	Bent 10, Westernmost Row of Piles Only	98.49
Capitol Aerial Guideway	Bent 14, Westernmost Row of Piles Only	97.96

3. At existing median, drive piles in oversized predrilled holes at the locations and to the bottom of hole elevations shown in the following table:

Structure	Bent Number	Bottom of Hole Elevation
Capitol Aerial Guideway	Bent 60	90.66
Capitol Aerial Guideway	Bent 61	90.66
Capitol Aerial Guideway	Bent 64	92.60
Capitol Aerial Guideway	Bent 65	93.30
Capitol Aerial Guideway	Bent 71	96.39
Capitol Aerial Guideway	Bent 72	96.29

D. Driving Equipment:

1. Install driven piles using an authorized impact hammer. The impact hammer must be steam, hydraulic, air, or diesel, and must be able to develop sufficient energy to drive the pile at a penetration rate of not less than 1/8 inch per blow at the nominal driving resistance shown.
2. Do not use vibratory hammers, oscillators, or rotators to install driven piles.
3. Hammers with an external combustion engine that are not single action must have a transducer that records ram velocity.
4. Double acting diesel hammers with internal combustion engines must have a transducer that records bounce chamber pressure.
5. Steam or air hammers must have boiler or air capacity of at least that specified by the manufacturer. The boiler or air compressor must be equipped with an accurate pressure gauge.
6. Maintain the valve mechanism and other parts of steam, air, or diesel hammers such that the length of stroke and number of blows per minute for which the hammer is designed is attained. Do not use inefficient steam, air, or diesel hammers.
7. You may use followers or underwater hammers for driving piles if authorized. If using a follower or underwater hammer, verify its efficiency by furnishing the first pile in each bent

or footing sufficiently long and drive the pile without the use of a follower or underwater hammer.

E. Pile Driving:

1. Drive piles to the position and line shown. Piles materially out of line must be rejected. Dispose of rejected piles that interfere with the work. You must remove or cut off and abandon in place any rejected piles that do not interfere with the work.

    a. Remove and replace rejected steel pipe piles, or drive a new pipe pile adjacent to the rejected pipe pile. Fill rejected pipe piles that cannot be removed with concrete. If a new pipe piles is driven to replace a rejected pipe pile, enlarge the footing.

2. When driving in groups or in closely-spaced pile conditions or when driving in long continuous runs, sequence pile driving of subsequent piles to prevent lateral or vertical displacement of previously driven piles.
3. 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.
4. Maintain the hammer coaxial with the pile during the driving operation by using driving heads or driving blocks that hold the pile in position directly under the hammer. Carefully plumb the leads and the pile before driving. Take care during driving to prevent and correct any tendency of piles to twist or rotate. Take special precautions to ensure against overstressing or leading away from a true position when driving.
5. 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.
6. Re-drive any pile that is raised during driving of adjacent piles to the original tip elevation.
7. Splice piles only by methods and at places approved by VTA in writing.
8. Cut off driven piles at the elevations shown and anchor them to the structure. Do not damage the pile below cutoff. Cutoffs must become the property of the Contractor and must be removed from the site. Repair of piles that are damaged when cut off requires written approval of VTA.
9. Install driven piles using the impact hammer approved in the driving system submittal.
10. All production piling must be driven after excavation of pile cap is complete. Driving piles from grade and then excavating will not be allowed.
11. Complete driving of all piles in a bent before proceeding to next bent.
12. Production piles for each construction stage must be fabricated and driven after the specified tip elevations have been established from the corresponding stage of the indicator and load test pile programs. Drive all piles to the specified tip elevations.
13. Except as required for splicing piles, drive piles continuously until the nominal driving resistance and the specified tip elevations have been reached. Driving criteria to develop the individual pile capacities specified will be based on the driving system proposed by the Contractor and the soil conditions along the different portions of the alignment. The driving criteria will be used during production pile driving in evaluating the individual pile capacities.

    a. If unforeseen causes arise to prevent continuous driving, the delay time must be recorded at the corresponding pile depth on the pile driving record. The blow counts for the first three feet after the delay will not necessarily be considered as termination resistance.

14. Although drilling may be used or required prior to driving the piles, it is still conceivable that hard driving may still be encountered above the specified tip elevation. If refusal driving resistance is encountered within the last five feet of penetration, driving must be stopped when approved by the Field Geotechnical Engineer. Refusal driving is dependent on the

driving system and therefore will be defined during construction by the Field Geotechnical Engineer.

15. If additional piles are required in areas of "soft" driving conditions, they must be driven at locations designated by the Structural Engineer of Record.
16. Pile Marking: Prior to driving, mark or paint depth marking at 5 foot intervals throughout pile lengths and label distance of each mark from tip of pile. In addition, paint each pile with secondary marks at one-foot intervals. Piles must be oriented in the leads such that the pile markings will be readily visible to the Field Geotechnical Engineer. Provide supplementary markings on the leads and hammer for reference as requested by the Field Geotechnical Engineer.
17. Cut-offs: Piles which have reached refusal, as determined by the Field Geotechnical Engineer, must be cut off to a true plane at the elevations shown on the plans, or as directed by the Field Geotechnical Engineer. Cutting must be done with approved equipment that must not fracture or damage the area below the cut surface. Piles must be driven or cut off within the tolerances of one inch above and one inch below the intended cut-off elevations. All pile cut-offs must be made without additions to the Contract price. Disposal of the cut-off portions of the piles must be the responsibility of the Contractor. All piles must be surveyed prior to cut-off in order to determine butt elevation.
18. Upon completion of the driving of each pile, the Contractor must, by surveying techniques, provide the pile butt elevation and the plan position of the pile to the Field Geotechnical Engineer. This information must be maintained and provided to the Field Geotechnical Engineer on a daily basis. All piles must be surveyed prior to cut-off in order to determine tip elevations.
19. Make vertical heave checks of piles within pile groups as directed by the Field Geotechnical Engineer using surveying techniques. The heave checks must be made following completion of the driving of the initial pile in the group, and after the driving of the final pile within that group. Piles which have heaved more than 1/4 inch must be re-driven to the driving criteria established by the Field Geotechnical Engineer.

F. Steel Pipe Piles:

1. Protect the heads of piles from direct impact of the hammer by using an approved cushion driving block or shoe. Maintain the head block or shoe in good condition during the entire driving operation.
2. Provide special driving tips or heavier pile sections or take other authorized measures to prevent damage to steel piles, steel shells, or steel casings during installation.
3. 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 60, Metal Welding, and this Section for welding requirements.

   a. Steel pipe pile splices that are made in the field must be complete joint penetration (CJP) groove welds.
   b. Field welds made in the horizontal position where the longitudinal pipe axis is vertical must be single-bevel groove welds.
   c. Do not water quench field welds. Allow welds to cool unassisted to ambient temperature.
   d. Remove ends of steel pipe piles to be spliced that have been damaged during driving to a sound and uniform section. Pipe ends must comply with the tolerances for diameter, edge alignment, and roundness as specified in these Technical Specifications. Pipe ends must be field cut using automated guided cutting equipment. Do not use manual flame cutting.
   e. The Contractor may re-drive steel pipe piles to prevent pile set-up if the field welded splice remains at least three feet above the work platform until the splice has been authorized by VTA.

4. Remove rejected pipe pile and replace with new pipe. When rejected pipe pile cannot be removed, furnish and install replacements. Cut off abandoned pipe three feet below the structure and fill the abandoned pipe with concrete with a minimum 28-day compressive strength of 3,000 pounds per square inch. Backfill and compact holes.
5. 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 must be the basis for rejection of the pile. The Contractor must verify the integrity of the pile.
6. When attaching handling devices to steel pipe piles, align the welds parallel to the axis of the pile. Welds must comply with the requirements for attaching backing rings, as specified in Article 2.02, “Welding of Steel Pipe Piles,” herein. Permanent bolted connections must be corrosion resistant
7. Pipe piles must be installed open ended and no internal plates must be used, unless shown otherwise in the plans.
8. In addition to driving, it is anticipated that drilling through the center of open-ended pipe piles to reach the specified tip elevation may be necessary. The diameter of the drilled hole must be less than the inside diameter of the piling. Equipment or methods used for drilling holes must not cause quick soil conditions or cause scouring or caving of the hole. Drilling must not be used within 20 feet of the specified tip elevation.

    a. Material resulting from drilling through the center of open-ended pipe piles must be disposed of as surplus material, as specified in Section 31 00 00, Earthwork.

9. Cleaning Out Pipe Piles: Pipe piles partially filled with reinforced concrete must be free of any soil, rock, or other material deleterious to the bond between concrete and steel pipe within the limits of reinforced concrete fill prior to placing reinforcement and concrete.

    a. Inspect pipe for internal damage and misalignment and for the presence of water, and correct damaged or defective conditions before placement of concrete. Pipe piles partially filled with water within the limits of reinforced concrete fill must be dewatered or concrete-filled using the tremie method.
    b. Do not disturb the foundation material surrounding the pile when cleaning out the pipe pile.
    c. After the pipe piles have been cleaned out, the pile must be constructed expeditiously in order to prevent deterioration of the surrounding foundation material from the presence of water. Deteriorated foundation materials near the limits of the reinforced concrete fill, including materials that have softened, swollen, or degraded, must be removed and disposed of outside the right of way.
    d. Material resulting from cleaning out the pipe piles must be disposed of as surplus material, as specified in Section 31 00 00, Earthwork.

10. The reinforcement must be placed and secured symmetrically about the axis of the pile and must be securely blocked to clear the sides of the open ended pipe pile.
11. Minimum pile spacing must be three pile widths center to center unless otherwise directed.
12. Piles must be held plumb before and during driving. Drilling and predrilling must also be plumb. Piles must be installed within the installation tolerances specified in Article 1.07, herein. Pulling piles into position is not permitted.

    a. Drive substitute piles, at locations established by VTA, where driven piles exceed specified tolerances. Any increase in pile cap dimensions or reinforcing caused by out-of-position piles will be at the Contractor's expense.

13. Each and every indicator and load test pile must be driven with the same hammer. The same hammer must be used for the production piles.

G. Precast Prestressed Concrete Piles:

1. Precast, prestressed concrete piles must not be driven until at least 14 days after casting.
2. Protect the heads of driven piles from direct impact of the hammer with a cushion driving block so that no cracking, spalling, or chipping occurs. Maintain the cushion in good condition during the entire driving operation. Arrange the cushion driving block such that any reinforcing bars projecting above the pile are not displaced or damaged during driving.
3. If piles have extended reinforcing steel and protective concrete for driving, remove such protective concrete to expose the reinforcing steel upon completion of driving.
4. 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.

H. Re-Driving: If behavior of any pile causes suspicion as to the reliability of the individual pile capacity value when the pile tip has reached the specified tip elevation, as determined by the Geotechnical Engineer of Record, the pile must be allowed to stand for a “set up” time without driving. The “set up” time must be at least five days. After the required “set up” time has elapsed, two piles or 10 percent of such piles in a footing, whichever is greater, must be re-driven. The Geotechnical Engineer of Record will designate which piles are to be re-driven. Re-driving must consist of operating the driving hammer at full rated energy on the pile and then measuring the individual pile capacity of the pile.

1. If the required individual pile capacity has been attained for each pile designated to be re-driven, then the remaining piles in that footing must be considered satisfactory and further driving will not be required. If re-driving said designated piles demonstrates that the required individual pile capacities have not been attained, all piles in that footing must be re-driven until the required individual pile capacities have been reached.
2. Contractor, by surveying techniques, must determine the pile butt elevation immediately after re-driving, and provide the survey information to VTA.

I. Difficult Pile Installation:

1. The driving resistance is expected to increase as consecutively driven piles densify the soil layers being penetrated.
2. If you encounter obstructions to driving, provide special driving tips or heavier pile sections, subexcavate below the bottom of footing, or take other measures to prevent damage to the pile during driving. The Contractor must be responsible for driving piles to the specified tip elevations established during the indicator and load test pile program.

    a. The method and equipment used for penetrating any hard structure and passing through any buried obstructions must be the responsibility of the Contractor. No pile location must be abandoned because of rocks or other obstructions until VTA is satisfied that all available and practical means of driving the pile have been exhausted.

3. If unable to drive the pile to the specified tip elevation, replace the pile with another pile at a location established by VTA.
4. Piles abandoned because of obstructions encountered before reaching the required embedment depth will be rejected.

J. Damaged Piles

1. General: Any piles driven into a previously driven pile automatically rejects both piles. Leave all pile heads sound; repair or replace damaged heads. Replace piles whose handling or driving record indicated possible damage or defect; replace as directed with a substitute

pile at no expense to VTA. Do not drive piles damaged or suspected of damage until inspected and approved by VTA.

2. Driving Damage: Piles damaged during driving or construction operations must be repaired to the satisfaction of VTA, or replaced at the expense of the Contractor.
3. VTA will reject any pile that is improperly driven, broken, or shows partial collapse to an extent as to materially decrease its nominal resistance.
4. Any pile driven out of the position and vertical tolerances set in Article 1.07 herein must be cause for rejection.
5. Methods for correcting piles out of vertical tolerance must be completed in accordance with this Section.

3.08 FIELD QUALITY CONTROL AND ASSURANCE

A. In addition to the sampling, testing, and inspections specified herein, the Independent Testing Agency must perform the following inspections and testing:

1. Verify piling materials, sizes, lengths, and workmanship comply with these Technical Specifications.
2. Prior to beginning pile driving operations, verify the placement locations and layout of the piles.
3. Quality control inspections and testing of welding in accordance with the provisions of Section 05 05 60, Metal Welding.
4. Reinforcement and concrete inspections in accordance with Section 03 20 00, Concrete Reinforcing, Section 03 30 00, Cast-in-Place Concrete, and Section 03 41 00, Structural Precast Concrete of these Technical Specifications.

B. The Field Geotechnical Engineer will oversee and/or perform the following observations and inspections:

1. Full time inspection of pile driving operations including predrilling operations, and driving of indicator and load test piles. No pile driving operations must be done without the presence of the Field Geotechnical Engineer.
2. Record the driving resistance in blows per foot for all piles and prepare pile driving reports that certify the design pile capacity.
3. Provide letter certifying pile installation is complete and in accordance with the plans and these Technical Specifications prior to the placement of concrete.

END OF SECTION 31 62 00

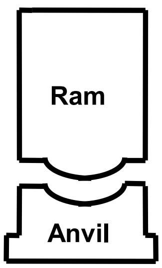
ATTACHMENT FOLLOWS

PILE AND DRIVING DATA FORM

Structure Name: ____

Contract No.: ______________________ Project: ______________________

Pile Driving Contractor or Subcontractor (Pile Driven By): ______________________



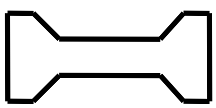
Hammer

Manufacturer:______________________ Model:______________
Type:__________________________Serial No.:______________
Min Rated Energy: _____ at ___ Length of Stroke ____ Fuel Setting
Max Rated Energy: _____ at ___ Length of Stroke ____ Fuel Setting
Ram Weight:______________________________________kips

Modifications: ______________________________________
____
____

Capblock (Hammer Cushion)

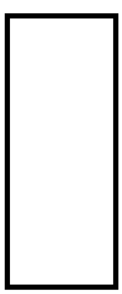
Material:____
Thickness:______________in Area:____________________in^2
Modulus of Elasticity - E:____________________________ksi
Coefficient of Restitution - e:______________________________



Pile Cap

Helmet
Bonnet
Anvil Block
Drivehead

Weight: kips



Pile

Pile Type:____
Length (In Leads):_______________________________________ft
Lb/ft.:_________________________Taper:____________________
Wall Thickness:____in
Cross Sectional Area:______________________________________in^2
Design Pile Capacity:______________________________________kips
Description of Splice:______________________________________
____
Tip Treatment Description:__________________________________
____

Note: If mandrel or follower is used to drive the pile, attach separate manufacturer's detail sheet(s) including weight and dimensions.

Submitted By: ____

Date: ______________________ Phone No.: ______________________

SECTION 31 63 29

DRILLED CONCRETE PIERS AND SHAFTS

PART 1 - GENERAL

1.01 SUMMARY

A. The scope of work outlined in this Section includes the following items of work, as detailed in these Technical Specifications, as shown on the plans or reasonably implied therefrom and is not limited to the following items:

1. Cast-in-drilled hole (CIDH) concrete piles
2. Excavation
3. Installation of Concrete Reinforcement
4. Concrete Placement
5. Temporary Steel Casing
6. Field Quality Control

1.02 RELATED SECTIONS

A. Section 6.6.2, Submittal, of the Special Conditions

B. Section 7.43, Submittal of Shop Drawings, Product Data and Samples, of the General Conditions

C. Section 02 43 13, BRT Ocala Station Relocation

D. Section 03 05 15, Portland Cement Concrete

E. Section 03 20 00, Concrete Reinforcing

F. Section 03 30 00, Cast-in-Place Concrete

G. Section 05 05 60, Metal Welding

H. Section 31 62 00, Driven Piles

1.03 REFERENCED STANDARDS

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. ASTM International (ASTM):

1.	ASTM A615/A615M	Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
2.	ASTM D1785	Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
3.	ASTM D2466	Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40

D. State of California, Department of Transportation (Caltrans):

1.	California Test 233	Method of Ascertaining the Homogeneity of Concrete in Cast-In-Drilled-Hole (CIDH) Piles Using the Gamma-Gamma Test Method
2.	California Test 556	Method of Test for Slump of Fresh Portland Cement Concrete

E. State of California, Department of Transportation (Caltrans), Standard Specifications 2018:

1.	Section 49	Piling

1.04 REGULATORY REQUIREMENTS

A. Comply with applicable requirements of the California Code of Regulations, Title 24, Part 2, 2019 California Building Code, Chapters 18 and 18A, "Soils and Foundations."

1.05 DEFINITIONS

A. The words and terms used in these Technical Specifications conform to the definitions given in ACI 336.1.

B. The terms "drilled shaft," "pier," and "cast-in-drilled-hole (CIDH) pile" are used interchangeably.

C. Control Zone: Zone that has the same subsurface profile and engineering properties as a corresponding support location.

D. Nominal Resistance: Design capacity required to resist the factored axial loads.

E. Dry Hole: A drilled hole that requires no work to keep it free of water.

F. Dewatered Hole: A drilled hole that satisfies all of the following criteria:

1. Accumulates no more than 12 inches of water at the bottom during a one hour period without any pumping from the hole.
2. Has no more than three inches of water at the bottom immediately before placing concrete.
3. Does not require temporary casing to control the groundwater.

1.06 SUBMITTALS

A. General: Submittals for drilled concrete piers and shafts must be made in accordance with the provisions in Section 6.6.2, Submittal, of the Special Conditions, Section 7.43, Submittal of Shop Drawings, Product Data and Samples, of the General Conditions, and these Technical Specifications.

B. Pile Installation Plan

1. Submit a pile installation plan. Include complete descriptions, details, and supporting calculations for the following items:

    a. Concrete mix design, certified test data, and trial batch reports
    b. Drilling or coring methods and equipment

        1) Include a list of all proposed equipment, including, but not necessarily limited to, cranes, drills, augers, bailing buckets, final cleaning equipment, and drilling units. The list must include the description, age, and capacities of the proposed equipment, along with the project history of the drilling equipment demonstrating the successful use of the equipment on cast-in-drilled-hole concrete piles of equal or greater diameter and depth and in similar subsurface geotechnical conditions.

    c. Proposed method for casing installation and removal, if necessary
    d. Methods for placing, positioning, and supporting bar reinforcement
    e. Methods and equipment for determining:

        1) Depth of concrete
        2) Theoretical volume of concrete to be placed, including the effects on volume if casings are withdrawn
        3) Actual volume of concrete placed

    f. Methods and equipment for cleaning the bottom of the drilled hole
    g. Methods and equipment for verifying the bottom of the drilled hole is clean before placing concrete
    h. Methods and equipment for preventing upward movement of reinforcement, including the means of detecting and measuring upward movement during concrete placement operations
    i. Drilling plan and sequence
    j. Concrete sequence and placement plan
    k. If inspection pipes are required, methods for ensuring the inspection pipes remain straight, undamaged, and properly aligned during concrete placement

2. For concrete placed under slurry, include complete descriptions, details, and supporting calculations in the pile installation plan for the following items:

    a. Concrete batching, delivery, and placing systems, including time schedules and capacities. Time schedules must include the time required for each concrete placing operation at each pile.
    b. Concrete placing rate calculations. If requested, base calculations on the initial pump pressures or static head on the concrete and losses throughout the placing system, including anticipated head of slurry and concrete to be displaced.
    c. Suppliers' test reports on the physical and chemical properties of the slurry and any proposed slurry chemical additives, including SDSs.
    d. Slurry testing equipment and procedures.
    e. Methods of removal and disposal of excavation, slurry, and contaminated concrete, including removal rates.
    f. Methods and equipment for slurry agitating, recirculating, and cleaning.
    g. Details of methods to ensure hole stability during excavation and concrete placement. The details must include a review of the suitability of the methods for the anticipated site and subsurface geotechnical conditions.

C. Drilling Equipment: Submit the proposed drilling equipment operational capacities or descriptions for downward force in pounds, torque in foot-pounds, rotational speed in revolutions per minute, rate of penetration in feet per hour, and number and type of drilling cutters or drilling teeth on drilling tool.

D. Records and Reports:

1. 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.
2. Acceptance Testing Reports:

    a. Prior to the performance of acceptance testing by the Independent Testing Agency, the Independent Testing Agency must submit the following reports in accordance with California Test 233. The reports must be sealed and signed by an engineer who is currently registered as a civil engineer in the State of California.

        1) Gamma-Gamma Probe Qualification Report
        2) Instrument Calibration Report
        3) Standard Reference Qualification Report

    b. The Independent Testing Agency must submit a pile acceptance test report in accordance with California Test 233 for all pile acceptance tests performed. The pile acceptance test reports must be sealed and signed by an engineer who is currently registered as a civil engineer in the State of California.

        1) If acceptance testing detects any pile anomalies, the Independent Testing Agency must complete Part 1 of the Pile Design Data Form and submit the Pile Design Data Form with the pile acceptance test report. The Pile Design Data Form is included as an attachment to these Technical Specifications.

3. Crosshole Sonic Logging Test Report: If ordered by VTA to perform crosshole sonic logging on a rejected pile, the Independent Testing Agency must submit a crosshole sonic logging test report. The reports must be sealed and signed by an engineer who is currently registered as a civil engineer in the State of California.

    a. The crosshole sonic logging test report must include the presentation of crosshole sonic logging logs for all tested tube pairs, and must include the following items:

        1) Presentation of the traditional nested signal peak (e.g. "waterfall") diagram as a function of time plotted versus depth.
        2) Computed pulse first arrival time (FAT) or pulse wave speed versus depth.
        3) Computed relative pulse energy or amplitude versus depth.

    b. A crosshole sonic logging log must be presented for each tube pair. Flaw or defect zones, if any, must be indicated on the logs and listed in a table. The horizontal and vertical extent of the flaw or defect, and its location, must be discussed in the report text.

E. 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.

F. Concrete Reinforcement: Provide submittals in accordance with the requirements of Section 03 20 00, Concrete Reinforcing.

G. Plastic Spacers:

1. If plastic spacers are proposed for use, submit the manufacturer's data and a sample of the plastic spacer. Allow 10 days for the review.

H. Qualifications of CIDH Pile Construction Personnel:

1. At least two weeks prior to the start of CIDH pile construction, submit four copies of a list identifying all on-site supervisors and drill rig operators to be used for CIDH pile construction. The list must contain a detailed summary of each individual’s experience in CIDH pile excavation operations and placement of assembled reinforcing cages and concrete in CIDH piles for at least three separate foundation projects within the last five years. A brief description of each project and the owner’s contact person’s name and current phone number must be included for each project listed.
2. On-site supervisors must have a minimum of two years of experience in supervising construction of CIDH pile foundation of similar diameter, depth, and difficulty to those shown in the plans, and similar subsurface geotechnical conditions to those described in the geotechnical report. The work experience must be direct supervisory responsibility for the on-site CIDH pile construction operations. Project management-level positions indirectly supervising on-site CIDH pile construction operations are not acceptable for this experience requirement.
3. Drill rig operators must have a minimum of one year of experience in the construction of CIDH pile foundations in similar subsurface geotechnical conditions to those described in the geotechnical report.
4. Work must not begin on any CIDH pile until the Contractor’s qualifications and field personnel are approved by the Engineer. The Engineer may suspend the CIDH pile construction operations if the Contractor substitutes field personnel without prior approval by the Engineer. The Contractor must be fully liable for the additional costs resulting from the suspension of work, and no adjustments in contract time resulting from such suspension of work will be allowed.

I. Qualifications of Personnel Performing Acceptance Testing and Crosshole Sonic Logging:

1. At least two weeks prior to the start of CIDH pile construction, submit qualifications of the Independent Testing Agency’s personnel to perform pile acceptance testing, for approval by the VTA. Include a detailed summary of each individual’s experience in gamma-gamma logging of CIDH piles for at least three separate foundation projects within the last three years.
2. At least two weeks prior to the start of CIDH pile construction, submit qualifications of the Independent Testing Agency’s personnel to perform crosshole sonic logging, for approval by the VTA. Include a detailed summary of each individual’s experience in crosshole sonic logging of CIDH piles for at least three separate foundation projects within the last three years

J. 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 60, Metal Welding, for casing steel.

K. Concrete Placement Log: Submit the concrete placement log as an informational submittal within two business days of completion of concrete placement in the hole. The log must include the following information, at a minimum:

1. Show the pile location, tip elevation, cutoff elevation, dates of excavation and concrete placement, total quantity of concrete placed, length and tip elevation of any casing, and details of any hole stabilization method and materials used.
2. Include an 8-1/2 by 11 inch graph of concrete placed versus depth of hole filled as follows:

   a. Plot the graph continuously throughout concrete placement. Plot the depth of drilled hole filled vertically with the pile tip at the bottom and the quantity of concrete placed horizontally.
   b. Take readings at each five feet of pile depth, and indicate the time of the reading on the graph.

L. Slurry:

1. If slurry is used, submit a slurry test record as an informational submittal within two business days of completion of concrete placement in the hole.
2. If synthetic slurry is used, submit as an informational submittal the names and certifications of your employees who are trained and certified by the synthetic slurry manufacturer.

M. If inspection pipes are required, submit a log of the locations of inspection pipe couplers and pile reinforcing cage couplers as an informational submittal within two business days of completion of concrete placement in the hole.

N. Rejected Pile Testing Report:

1. If you perform testing on a rejected pile, submit this additional information in a report. The report must be sealed and signed by an engineer who is currently registered as a civil engineer in the State of California. Allow 10 days for the review and analysis of this report.

O. Mitigation Plans:

1. For each rejected pile to be mitigated, submit a mitigation plan for repair, supplementation, or replacement. The mitigation plan must comply with the specifications for Shop Drawings. The mitigation plan must and be sealed and signed by an engineer who is currently registered as a civil engineer in the State of California, except for either of the following conditions:

   a. Proposed mitigation will be performed under the current Caltrans-published version of ADSC Standard Mitigation Plan 'A' - Basic Repair without exception or modification.
   b. Engineer determines that the rejected pile does not require mitigation due to structural, geotechnical, or corrosion concerns, and you elect to repair the pile using the current Caltrans-published version of ADSC Standard Mitigation Plan 'B' - Grouting Repair without exception or modification.

2. Pile mitigation plans must include the following, at a minimum:

   a. Designation and location of the rejected pile.
   b. Review of the structural, geotechnical, and corrosion design requirements of the rejected pile.
   c. Step by step description of the mitigation work to be performed, including drawings if necessary. If the ADSC Standard Mitigation Plan is an acceptable mitigation method, include the most recent version.
   d. Assessment of how the proposed mitigation work addresses the structural, geotechnical, and corrosion design requirements of the rejected pile.

e. Methods for preservation or restoration of existing earthen materials.
f. List of any affected facilities. Include methods and equipment to be used for the protection of these facilities during mitigation.
g. Your name and the names of any subcontractors on each sheet.
h. List of materials with quantity estimates for the mitigation work and a list of personnel with their qualifications who will be performing the mitigation work.

3. For rejected piles to be repaired, include the following in the pile mitigation plan:

a. Assessment of the nature and size of the anomalies in the rejected pile
b. Provisions for access for additional pile testing, if requested

4. For rejected piles to be replaced or supplemented, include the following in the pile mitigation plan:

a. Proposed location and size of additional piles
b. Structural details and calculations for any modification to the structure to accommodate the replacement or supplemental piles

5. Replacement piles must comply with the Contract for CIDH concrete piles.

P. Mitigation Report:

1. If repairs are performed, submit a mitigation report as an informational submittal within ten days of completion of the repair. The report must state exactly what repair work was performed and quantify the success of the repairs relative to the submitted mitigation plan. The mitigation report must be sealed and signed by an engineer who is currently registered as a civil engineer in the State of California. The mitigation report must include your name and the names of any subcontractors on each sheet.

Q. Coring Logs and Concrete Cores:

1. If coring is performed, submit coring logs and concrete cores. Allow 10 days for the review.

1.07 QUALITY CONTROL AND ASSURANCE

A. Codes and Standards: Comply with all Federal, State and local codes and safety regulations.

B. Inspection by VTA and Other Governing and Regulatory Authorities: Allow VTA and other governing and regulatory authorities to perform testing and inspection of materials and practices associated with construction within their jurisdiction on the Worksite during business hours for the purpose of ensuring that the Work is in compliance with the requirements of the plans, these Technical Specifications, and other local, state and federal laws and regulations.

C. Contractor Quality Control:

1. Sampling, Testing and Inspection:

a. Hire an Independent Testing Agency to perform sampling, testing, and inspections in accordance with the provisions herein and Section 6.26, Quality Assurance and Quality Control Requirements, of the Special Provisions.

b. Wherever it is specified herein that sampling, testing, or inspection must be performed by the Contractor, it must be understood to mean that said sampling, testing, or inspection must be performed by the Independent Testing Agency.

c. Cooperate with and notify VTA at least 48 hours in advance of sampling, tests and inspections, being performed by the Independent Testing Agency. VTA may elect to observe these procedures. Provide samples and facilities for inspection to VTA without extra charge if requested.

d. The Independent Testing Agency must collect samples of materials for testing in accordance with the provisions outlined herein and as directed by VTA.

2. Qualifications of the Independent Testing Agency: Refer to Section 6.26, Quality Assurance and Quality Control Requirements, of the Special Provisions.

   a. Personnel performing pile acceptance testing must be supervised by an engineer who is currently registered as a civil engineer in the State of California. Personnel performing pile acceptance testing must have at least three years of experience in gamma-gamma logging. The qualifications of personnel performing pile acceptance testing must be submitted to the Engineer for approval prior to beginning drilled pile construction.

   b. Personnel performing crosshole sonic logging and providing interpretation of results must be supervised by an engineer who is currently registered as a civil engineer in the State of California. Personnel performing crosshole sonic logging must have at least three years of experience in crosshole sonic logging testing. The qualifications of personnel performing crosshole sonic logging must be submitted to the Engineer for approval prior to beginning drilled pile construction.

3. Notify VTA at least 48 hours prior to performing any CIDH pile construction operations.

D. VTA Quality Assurance:

   1. VTA will monitor the implementation of the Contractor's quality control programs through observation, inspection, sampling and testing in accordance with Section 6.26, Quality Assurance and Quality Control Requirements, of the Special Provisions.

   2. Failure of VTA to detect work or material which is defective or contrary to these Technical Specifications must not prevent later rejection when such work or material is discovered, nor must it obligate VTA for final acceptance.

E. Construction Standards: Drilled shaft foundations must be constructed in accordance with applicable requirements of ACI 336.1 and ADSC's "Standards and Specifications for the Foundation Drilling Industry."

F. Design Criteria:

   1. Drilled shaft foundations must consist of monolithically cast-in-place concrete piles of the sizes indicated.

   2. Shaft foundations must be straight cylindrical shaft type as indicated.

   3. Shaft foundations must extend from the indicated concrete cutoff elevation to the indicated tip elevation.

G. Installation Tolerances:

   1. For CIDH concrete piles with a pile cap, the horizontal tolerance at the center of each pile at pile cut-off is the larger of 1/24 of the pile diameter or 3 inches. The horizontal tolerance for

the center-to-center spacing of two adjacent piles is the larger of 1/24 of the pile diameter or three inches.

2. The axis of the drilled hole must not deviate from plumb more than 1-1/2 inches per ten feet of length.
3. Bottom Diameter: minus zero, plus 6 inches, measured in any direction.
4. Maximum bottom level tolerance: plus or minus 2 inches.

H. Inspection of Shaft Excavations:

1. The Contractor must provide equipment for checking the dimensions and alignment of each shaft excavation. Dimensions and alignment must be determined by the Contractor. Final shaft depths must 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 must have less than 1/2 inch of sediment at the time of placement of concrete. Shaft cleanliness may be determined by VTA by visual inspection.

I. Preconstruction Meeting:

1. Schedule and hold a preconstruction meeting for CIDH concrete pile construction at least 5 business days after submitting the pile installation plan and at least 10 days before the start of CIDH concrete pile construction. You must provide a meeting facility.
2. The meeting must include VTA, your representatives, and any subcontractors involved in CIDH concrete pile construction.
3. The purpose of this meeting is to establish contacts and communication protocol between you and your representatives, any subcontractors, and VTA, and review the construction process, acceptance testing, and anomaly mitigation of CIDH concrete piles.
4. VTA conducts the meeting. Be prepared to discuss the following items:

   a. Pile placement plan, dry and wet
   b. Acceptance testing, including gamma-gamma logging, cross-hole sonic logging, and coring
   c. Pile Design Data Form
   d. Mitigation process
   e. Timeline and critical path activities
   f. Structural, geotechnical, and corrosion design requirements
   g. Future meetings, if necessary, for pile mitigation and pile mitigation plan review
   h. Safety requirements, including Cal/OSHA and Tunnel Safety Orders

J. Test Batch:

1. Concrete Placed Under Slurry:

   a. Before placing concrete under slurry, produce a concrete test batch and transport it to the Worksite under the same conditions and in the same time frame anticipated during the placement of concrete in the piles.
   b. At the Worksite, place the test batch concrete in an excavated hole lined with plastic or suitable container to allow for testing. Placing concrete under slurry is not required. The test batch must demonstrate that the proposed mix design will achieve the minimum required slump after the specified set period.
   c. Do not vibrate or agitate the concrete during the set period.

d. The Independent Testing Agency must test the concrete for slump under California Test 556. In addition to meeting the specified nominal slump, the slump of the concrete must comply with the requirements shown in the following table:

Slump Requirements

Time required to place concrete, T (hours) (See Note A)	Minimum set period before testing (hours) (See Note B)	Slump, after set period (inches)
T less than or equal to 2	2T	Greater than or equal to 7
T greater than 2	T + 2	Greater than or equal to 7

Note A: As described in the pile installation plan
Note B: The set period starts at the start of concrete placement.

e. After testing, dispose of the concrete test batch.

K. Qualifications:

1. If synthetic slurry is used, your employees who will be providing technical assistance in the slurry activities must be trained and certified by the synthetic slurry manufacturer to show their competency to perform inspection of slurry operations.
2. Welding and welders' qualifications must conform to the applicable requirements of Section 03 20 00, Concrete Reinforcing, and Section 05 05 60, Metal Welding.

1.08 SEQUENCING AND SCHEDULING

A. Unless otherwise authorized by VTA, drilling the hole and placing reinforcement and concrete in the hole must be performed in a continuous operation.

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.

1.09 SITE AND FOUNDATION CONDITIONS

A. Foundation Investigations:

1. The foundation investigations and other reports of the soil and subsurface conditions at the Worksite are available. The Contractor must read and be thoroughly familiar with the following available investigations and reports prior to bidding:

   a. "Eastridge to BART Regional Connector Capitol Expressway Light Rail Project 95% Design Phase Geotechnical Report," dated April 2020, by Parikh Consultants, Inc.

2. The data presented in the reports are not intended as representations or warranties of the continuity of such conditions and are made available only for convenience of the Contractor. Soil conditions between borings may vary in an irregular manner. It is expressly understood that the VTA, the Geotechnical Engineer of Record, and the Structural Engineer of Record will not assume any responsibility for such variations that may exist, nor for any interpretations, deductions, or conclusions that the Contractor may make from information made available by VTA.

3. The Contractor must not be relieved of liability under the Contract for any loss sustained as a result of any variance between conditions indicated or conclusions reached from the foundation investigations and the actual conditions encountered during the course of the work.

B. Examination of Worksite: The Contractor may examine the Worksite and make his own subsurface explorations to evaluate the CIDH pile construction conditions.

C. Location of Pipes, Sewers, Utilities and other Facilities: Do not commence work until the location and extent of all existing pipes, sewers, utilities and other facilities are determined. Do not commence pile installation work until all facilities designated for removal have been excavated in their entirety and the resulting excavations properly backfilled.

D. Accept the Worksite in its present condition.

E. Difficult Pile Installation:

1. Expect difficult pile installation due to the conditions shown in the following table:

Pile Location		Conditions
Structure	Support Location	
Capitol Aerial Guideway	Abutment 1	Traffic control, staged construction, noise control, potential high ground water, granular material, raveling or caving soils, proximity to underground utilities
Capitol Aerial Guideway	Bent 2	Traffic control, staged construction, noise control, potential high ground water, granular material, raveling or caving soils, proximity to underground and overhead utilities
Capitol Aerial Guideway	Bent 3	Traffic control, staged construction, noise control, potential high ground water, granular material, raveling or caving soils, proximity to underground and overhead utilities
Capitol Aerial Guideway	Bent 4	Traffic control, staged construction, noise control, potential high ground water, granular material, raveling or caving soils, proximity to underground and overhead utilities
Capitol Aerial Guideway	Bent 5	Traffic control, staged construction, noise control, potential high ground water, granular material, raveling or caving soils, proximity to underground and overhead utilities
Capitol Aerial Guideway	Bent 6E	Traffic control, staged construction, noise control, potential high ground water, granular material, raveling or caving soils, proximity to underground utilities
BRT Ocala Station	-	Traffic control, staged construction, noise control, potential high ground water
Shelter Canopy at Eastridge Station	-	Traffic control, staged construction, noise control, potential high ground water

1.10 MEASUREMENT AND PAYMENT

A. Measurement: Cast-in-Drilled-Hole Concrete Piling of the various sizes listed in the Schedule of Quantities and Prices must be measured by the linear foot.

1. The payment quantity for Cast-in-Drilled-Hole Concrete Piling of the various sizes listed in the Schedule of Quantities and Prices is the length measured along the longest side of the pile from the specified tip elevation shown to the plane of pile cutoff.

B. Payment: The contract price paid per linear foot for Cast-in-Drilled-Hole Concrete Piling of the various sizes listed in the Schedule of Quantities and Prices must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing cast-in-drilled hole concrete piling complete in place, as shown on the plans, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefor.

C. Full compensation for furnishing all bar reinforcing steel for cast-in-drilled-hole concrete piling with a diameter of 24 inches and larger must be considered as included in the bid item for Bar Reinforcing Steel of the various types listed in the Schedule of Quantities and Prices, and no additional compensation will be allowed therefor.

D. Full compensation for furnishing and installing cast-in-drilled-hole concrete piling and reinforcement for canopy structures and various systems items of work, including, but not necessarily limited to, traffic signals, traction electrification systems, and LTR signals, must be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefor.

E. Acceptance testing, including gamma-gamma logging, crosshole sonic logging, and mitigation and repair of rejected cast-in-drilled-hole concrete piling will not be measured separately for payment, and no additional compensation will be allowed therefor.

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, except deformed bars complying with ASTM A615/A615M, Grade 60 may be used.

B. Concrete: Conform to applicable requirements of Section 03 30 00, Cast-in-Place Concrete, and Section 03 05 15, Portland Cement Concrete.

1. Unless otherwise shown on the plans, concrete must have a minimum 28-day compressive strength of 3,600 pounds per square inch.
2. Prepare separate mix designs for each class of concrete.
3. Slump and Penetration: Refer to Section 03 05 15, Portland Cement Concrete, for requirements.
4. Concrete Placed Under Slurry:

    a. Slump: Refer to Section 03 05 15, Portland Cement Concrete, for requirements.

b. Concrete placed under slurry must contain at least 675 pounds of cementitious material per cubic yard and be proportioned to prevent excessive bleed water and segregation.

c. For concrete placed under slurry, the combined aggregate gradation must comply with the 1/2-inch maximum gradation or the 3/8-inch maximum gradation specified in Section 03 05 15, Portland Cement Concrete.

5. Prequalify the concrete under Section 03 05 15, Portland Cement Concrete.
6. The combined aggregate gradation must comply with the 1-inch, 1/2-inch, or 3/8-inch maximum gradation specified in Section 03 05 15, Portland Cement Concrete.

C. Temporary Steel Casing:

1. Furnish temporary steel casings where shown and where necessary to control water or to prevent quick soil conditions or caving of the hole.
2. Place temporary casings tight in the hole.
3. Temporary steel casing must be watertight and of sufficient strength to withstand the loads from installation, removal, lateral concrete pressures, and earth pressures.
4. Temporary steel casing must be noncorrugated with smooth surfaces.
5. Temporary steel casing must be clean and free of hardened concrete.

D. Permanent Steel Casing:

1. Permanent steel casing and driven steel shell must comply with section 49-2.02, "Steel Pipe Piling," of the Caltrans Standard Specifications.

E. Slurry:

1. Mineral Slurry:

a. Mineral slurry must comply with the requirements shown in the following table:

Mineral Slurry Requirements (See Note A)

Quality characteristic	Test method	Requirement
Density Before placement in the drilled hole and during drilling (pounds per cubic foot) Before final cleaning and immediately before placing concrete (pounds per cubic foot)	Mud weight (density), API RP 13B-1 section 4	64.3–69.1 (See Note B) 64.3–75.0 (See Note B)
Viscosity Bentonite (sec/qt) Attapulgite (sec/qt)	Marsh funnel and cup. API RP 13B-1, section 6.2	28–50 28–40
pH	Glass electrode pH meter or pH paper	8–10.5
Sand content Before final cleaning and immediately before placing concrete (percent)	Sand, API RP 13B-1, section 9	≤ 4.0

Note A: Slurry temperature must be at least 40 degrees Fahrenheit when tested
Note B: If authorized, you may use slurry in salt water. The allowable density of slurry in salt water may be increased up to two pounds per cubic foot.

b. Mineral slurry must be mixed and thoroughly hydrated in slurry tanks. Sample and test slurry from the slurry tanks before placement in the drilled hole.

c. Recirculate or continuously agitate slurry in the drilled hole.

d. For recirculated slurry:

   1) Remove drill cuttings from the slurry before discharging the slurry back into the drilled hole.
   2) Sample and test slurry at least every two hours after starting its use until tests show that the samples taken from the slurry tank and from within two feet of the bottom of the hole have consistent specified properties. Once consistent properties have been achieved, sample slurry at least every four hours as long as the specified properties remain consistent.

e. For nonrecirculated slurry:

   1) Sample and test slurry from the drilled hole at least every two hours after starting its use. Sample the slurry at mid-height and near the bottom of the hole.
   2) Recirculate slurry if tests show samples taken from mid-height and within two feet of the bottom of the hole do not have consistent specified properties.

f. Sample and test slurry before final cleaning of the bottom of the hole and again just before placing concrete. Sample the slurry at mid-height and within two feet of the bottom of the hole. Do not start cleaning the bottom of the hole or placing the concrete until tests show that the samples have consistent specified properties.

2. Synthetic Slurry:

a. The synthetic slurry must be one of the materials shown in the following table:

Material	Manufacturer
SlurryPro CDP	KB INTERNATIONAL LLC 735 BOARD ST STE 209 CHATTANOOGA TN 37402 (423) 266-6964
Super Mud	PDS CO INC 105 W SHARP ST EL DORADO AR 71731 (870) 863-5707
Shore Pac GCV	CETCO CONSTRUCTION DRILLING PRODUCTS 2870 FORBS AVE HOFFMAN ESTATES IL 60192 (800) 527-9948
Terragel or Novagel Polymer	GEO-TECH SERVICES LLC 220 N. ZAPATA HWY STE 11A-449A LAREDO TX 78043 (210) 259-6386
BIG FOOT	MATRIX CONSTRUCTION PRODUCTS 50 S MAIN ST STE 200 NAPERVILLE IL 60540 (877) 591-3137
POLY-BORE	BAROID INDUSTRIAL DRILLING PRODUCTS 3000 N SAM HOUSTON PKWY EAST HOUSTON TX 77032 (877) 379-7412

b. Use synthetic slurries in compliance with the manufacturer's instructions. Synthetic slurries shown in the above table may not be appropriate for a given Worksite.

c. Do not use synthetic slurries in holes drilled in primarily soft or very soft cohesive soils as determined by the Engineer.

d. Sample and test synthetic slurries:

1) When the slurry temperature is at least 40 degrees Fahrenheit.
2) At mid-height and within two feet of the bottom of the hole.
3) During drilling to verify the slurry properties.
4) When drilling is complete but before final cleaning of the bottom of the hole. When samples comply with the requirements shown in the tables for the slurry material selected, clean the bottom of the hole of any loose or settled material.
5) After final cleaning and immediately before placing concrete.

e. SlurryPro CDP synthetic slurry must comply with the requirements shown in the following table:

SlurryPro CDP (See Note A)

Quality characteristic	Test method	Requirement
Density During drilling (pounds per cubic foot) Before final cleaning and immediately before placing concrete (pounds per cubic foot)	Mud weight (density), API RP 13B-1, section 4	≤ 67.0 (See Note B) ≤ 64.0 (See Note B)
Viscosity During drilling (sec/qt) Before final cleaning and immediately before placing concrete (sec/qt)	Marsh funnel and cup. API RP 13B-1, section 6.2	50–120 ≤ 70
pH	Glass electrode pH meter or pH paper	6.0–11.5
Sand content, percent by volume Before final cleaning and immediately before placing concrete (percent)	Sand, API RP 13B-1, section 9	≤ 1.0

Note A: Slurry temperature must be at least 40 degrees Fahrenheit when tested
Note B: If authorized, you may use slurry in salt water. The allowable density of slurry in salt water may be increased up to two pounds per cubic foot.

f. Super Mud synthetic slurry must comply with the requirements shown in the following table:

Super Mud (See Note A)

Quality characteristic	Test method	Requirement
Density During drilling (pounds per cubic foot) Before final cleaning and immediately before placing concrete (pounds per cubic foot)	Mud weight (density), API RP 13B-1, section 4	≤ 64.0 (See Note B) ≤ 64.0 (See Note B)
Viscosity During drilling (sec/qt) Before final cleaning and immediately before placing concrete (sec/qt)	Marsh funnel and cup. API RP 13B-1, section 6.2	32–60 ≤ 60
pH	Glass electrode pH meter or pH paper	8.0–10.0
Sand content, percent by volume Before final cleaning and immediately before placing concrete (percent)	Sand, API RP 13B-1, section 9	≤ 1.0

Note A: Slurry temperature must be at least 40 degrees Fahrenheit when tested
Note B: If authorized, you may use slurry in salt water. The allowable density of slurry in salt water may be increased up to two pounds per cubic foot.

g. Shore Pac GCV synthetic slurry must comply with the requirements shown in the following table:

Shore Pac GCV (See Note A)

Quality characteristic	Test method	Requirement
Density During drilling (pounds per cubic foot) Before final cleaning and immediately before placing concrete (pounds per cubic foot)	Mud weight (density), API RP 13B-1, section 4	≤ 64.0 (See Note B) ≤ 64.0 (See Note B)
Viscosity During drilling (sec/qt) Before final cleaning and immediately before placing concrete (sec/qt)	Marsh funnel and cup. API RP 13B-1, section 6.2	33–74 ≤ 57
pH	Glass electrode pH meter or pH paper	8.0–11.0
Sand content, percent by volume Before final cleaning and immediately before placing concrete (percent)	Sand, API RP 13B-1, section 9	≤ 1.0

Note A: Slurry temperature must be at least 40 degrees Fahrenheit when tested
Note B: If authorized, you may use slurry in salt water. The allowable density of slurry in salt water may be increased up to two pounds per cubic foot.

h. Terragel or Novagel Polymer synthetic slurry must comply with the requirements shown in the following table:

Terragel or Novagel Polymer (See Note A)

Quality characteristic	Test method	Requirement
Density During drilling (pounds per cubic foot) Before final cleaning and immediately before placing concrete (pounds per cubic foot)	Mud weight (density), API RP 13B-1, section 4	≤ 67.0 (See Note B) ≤ 64.0 (See Note B)
Viscosity During drilling (sec/qt) Before final cleaning and immediately before placing concrete (sec/qt)	Marsh funnel and cup. API RP 13B-1, section 6.2	45–104 ≤ 104
pH	Glass electrode pH meter or pH paper	6.0–11.5
Sand content, percent by volume Before final cleaning and immediately before placing concrete (percent)	Sand, API RP 13B-1, section 9	≤ 1.0

Note A: Slurry temperature must be at least 40 degrees Fahrenheit when tested
Note B: If authorized, you may use slurry in salt water. The allowable density of slurry in salt water may be increased up to two pounds per cubic foot.

i. BIG-FOOT synthetic slurry must comply with the requirements shown in the following table:

BIG-FOOT (See Note A)

Quality characteristic	Test method	Requirement
Density During drilling (pounds per cubic foot) Before final cleaning and immediately before placing concrete (pounds per cubic foot)	Mud weight (density), API RP 13B-1, section 4	 ≤ 64.0 (See Note B) ≤ 64.0 (See Note B)
Viscosity During drilling (sec/qt) Before final cleaning and immediately before placing concrete (sec/qt)	Marsh funnel and cup. API RP 13B-1, section 6.2	 30–125 55-114
pH	Glass electrode pH meter or pH paper	8.5–10.5
Sand content, percent by volume Before final cleaning and immediately before placing concrete (percent)	Sand, API RP 13B-1, section 9	 ≤ 1.0

Note A: Slurry temperature must be at least 40 degrees Fahrenheit when tested
Note B: If authorized, you may use slurry in salt water. The allowable density of slurry in salt water may be increased up to two pounds per cubic foot.

j. POLY-BORE synthetic slurry must comply with the requirements shown in the following table:

POLY-BORE (See Note A)

Quality characteristic	Test method	Requirement
Density During drilling (pounds per cubic foot) Before final cleaning and immediately before placing concrete (pounds per cubic foot)	Mud weight (density), API RP 13B-1, section 4	 62.58-65.8 (See Note B) 62.8-64.0 (See Note B)
Viscosity During drilling (sec/qt) Before final cleaning and immediately before placing concrete (sec/qt)	Marsh funnel and cup. API RP 13B-1, section 6.2	 50–80 50-80
pH	Glass electrode pH meter or pH paper	7.0–10.0
Sand content, percent by volume Before final cleaning and immediately before placing concrete (percent)	Sand, API RP 13B-1, section 9	 ≤ 1.0

Note A: Slurry temperature must be at least 40 degrees Fahrenheit when tested
Note B: If authorized, you may use slurry in salt water. The allowable density of slurry in salt water may be increased up to two pounds per cubic foot.

F. Inspection Pipes:

1. Inspection pipes must be schedule 40 PVC pipe complying with ASTM D1785 with a nominal pipe size of two inches.

2. Watertight PVC couplers complying with ASTM D2466 are allowed to facilitate pipe lengths in excess of those commercially available.

G. Plastic Spacers:

1. Plastic spacers must be of commercial quality and must comply with sections 3.4 and 3.5 of the Concrete Reinforcing Steel Institute's Manual of Standard Practice.
2. Plastic spacers must have at least 25 percent of their gross plane area perforated to compensate for the difference in the coefficient of thermal expansion between the plastic and concrete.

H. Grout:

1. Grout must consist of cementitious material and water and may contain an admixture if authorized. Do not exceed 5 gallons of water per 94 pounds of cement.
2. Cementitious material must comply with Section 03 05 15, Portland Cement Concrete, except supplementary cementitious materials are not required.
3. Water must comply with Section 03 05 15, Portland Cement Concrete. If municipally supplied potable water is used, the testing specified in Section 03 05 15, Portland Cement Concrete, is waived.
4. Admixtures must comply with Section 03 05 15, Portland Cement Concrete, except admixtures must not contain chloride ions in excess of 0.25 percent by weight.
5. For grout used to fill inspection pipes and cored holes used for gamma-gamma logging, the efflux time immediately after mixing must be at least 11 seconds. Determine the efflux time in accordance with California Test 541.
6. Grout used to backfill casings must comply with the following requirements:

    a. Aggregate must be used to extend the grout.
    b. Aggregate must consist of at least 70 percent fine aggregate and approximately 30 percent pea gravel, by weight.
    c. Fine aggregate must comply with Section 03 05 15, Portland Cement Concrete.
    d. Size of pea gravel must be such that 100 percent passes the 1/2-inch sieve, at least 85 percent passes the 3/8-inch sieve, and not more than 5 percent passes the no. 8 sieve.
    e. Grout must contain at least 845 pounds of cementitious material per cubic yard.
    f. Mix the grout as follows:

        1) Add water to the mixer followed by cementitious material, aggregates, and any admixtures.
        2) Mix the grout with mechanical mixing equipment that produces a uniform and thoroughly mixed grout.
        3) Agitate the grout continuously until the grout is pumped.
        4) Do not add water after initial mixing.

2.02 EXCAVATING AND DRILLING EQUIPMENT

A. Excavating and drilling equipment must 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 must 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 must 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.

C. All equipment used in the field must be fully operational and reliable. No time extensions will be allowed due to excessive equipment breakdowns, which may cause delays in cast-in-drilled-hole piling construction.

PART 3 - EXECUTION

3.01 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 plans or as directed by VTA. Avoid over excavation. Excavation must be performed through whatever materials are encountered to the dimensions, depths, and tolerances indicated. Bottoms of excavations must be level and flat.
2. 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.
3. Except for CIDH concrete piles for sound walls and retaining walls, you may propose to increase the diameter and revise the pile tip elevation of CIDH concrete piles with a diameter less than 2 feet.
4. For CIDH concrete piles for sound walls and retaining walls, you may propose to increase the diameter of CIDH concrete piles with a diameter less than 2 feet, except pile tip elevations must not be revised.
5. For CIDH concrete pile tolerances, refer to Article 1.06G, herein.
6. During excavation, do not disturb the foundation material surrounding the pile. Equipment or methods used for excavating holes must not cause quick soil conditions or cause scouring or caving of the hole.
7. For rock sockets, equipment and drill methods must not result in softened materials on the borehole walls.
8. If slurry is used during excavation, maintain the slurry level at a height required to maintain a stable hole, but not less than 10 feet above the piezometric head.
9. After excavation has started, construct the pile expeditiously to prevent deterioration of the surrounding foundation material from air slaking or from the presence of water. Remove and dispose of deteriorated foundation material, including material that has softened, swollen, or degraded, from the sides and the bottom of the hole.
10. Just before placing reinforcement or concrete, clean the bottom of the hole to remove any loose sand, gravel, dirt, and drill cuttings.
11. If caving occurs or deteriorated foundation material accumulates on the bottom of the hole, clean the bottom of the hole after placing reinforcement and before placing concrete in the hole. You must verify that the bottom of the hole is clean.
12. Remove water that has infiltrated the dewatered hole before placing concrete, as required for dewatered hole. Do not allow fluvial or drainage water to enter the hole.
13. If authorized, to control caving or water seepage, you may enlarge portions of the hole, backfill the hole with slurry cement backfill, concrete, or other material, and redrill the hole to the diameter shown. Backfill material at enlarged piles must be chemically compatible with concrete and steel, be drillable, and have the necessary strength required for the conditions.
14. Dispose of material resulting from placing concrete.

B. Ground Water Control:

1. Notify VTA immediately when ground water is encountered.

2. Suitable steel casings must be furnished and placed when necessary to control water. Drilling mud or chemical stabilizers must not be used unless permitted by VTA.

C. Inspection: After completion of excavation and prior to placement of reinforcing steel, the condition of the excavation may be inspected by VTA. 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.

3.02 INSTALLATION OF CONCRETE REINFORCEMENT

A. Where it is not practicable to deliver the cage assembly to the Worksite 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 one inch to the bottom of the hole is lost, remove cage and remove slough at bottom of hole.

F. Place and secure reinforcement. Securely block the reinforcement to provide the minimum clearance shown between the reinforcing steel cage and the sides of the drilled hole, casing, or steel shell.

G. Reinforcement for CIDH concrete piles with increased diameters and revised tip elevations must comply with the following:

1. Size and number of the reinforcing bars and hoops, the percentage of bars required to extend to the pile tip, and the size and pitch of spiral reinforcement must be the same as shown for the original piles.
2. Required length of the spiral reinforcement and of any reinforcing bars that do not extend to the pile tip must be at least the length that would have been required for the original specified or ordered tip elevation.
3. Diameter of the spiral or hoop reinforcement must remain the same as required for the original pile or may be increased to provide not less than the concrete cover required for the original pile. Provide positive means to ensure that the reinforcement is centered in the pile.

H. Unless otherwise shown, the bar reinforcing steel cage must have at least 3 inches of clear cover measured from the outside of the cage to the sides of the hole or casing.

I. Place spacers at least five inches clear from any inspection tubes.

J. Place plastic spacers around the circumference of the cage and at intervals along the length of the cage under the manufacturer's instructions.

K. For a single CIDH concrete pile supporting a column:

1. If the pile and the column share the same reinforcing cage diameter, this cage must be accurately placed as shown.
2. If the pile reinforcing cage is larger in diameter than the column cage:

    a. Maintain a clear horizontal distance of at least 3.5 inches between the two cages, if the concrete is placed under dry conditions.
    b. Maintain a clear horizontal distance of at least 5 inches between the two cages if the concrete is placed under slurry.
    c. The offset between the centerlines of the two cages must not exceed 6 inches.

3.03 INSTALLATION OF VERTICAL INSPECTION PIPES

A. For acceptance testing, install and test vertical inspection pipes as follows:

1. Log the location of the inspection pipe couplers and pile reinforcing cage couplers with respect to the plane of pile cutoff.
2. Cap each inspection pipe at the bottom. Extend the pipe from 3 feet above the pile cutoff to the bottom of the reinforcing cage. Provide a temporary top cap or similar means to keep the pipes clean before testing. If pile cutoff is below the ground surface or working platform, extend inspection pipes to 3 feet above the ground surface or working platform.
3. If any changes are made to the pile tip, extend the inspection pipes to the bottom of the reinforcing cage.
4. Install inspection pipes in a straight alignment and parallel to the main reinforcement. Securely fasten inspection pipes in place and provide protective measures to prevent misalignment or damage to the inspection pipes during installation of the reinforcement and placement of concrete in the hole. Construct CIDH concrete piles such that the relative distance of inspection pipes to vertical steel reinforcement remains constant.
5. After concrete placement is complete, fill inspection pipes with water to prevent debonding of the pipe.
6. Provide safe access to the tops of the inspection pipes.
7. After placing concrete and before requesting acceptance testing, test each inspection pipe in VTA's presence by passing a rigid cylinder through the length of pipe. The rigid cylinder must be 1-1/4-inch diameter by 4.5-foot long, weigh 12 pounds or less, and be able to freely pass down through the entire length of the pipe under its own weight and without the application of force.
8. When performing acceptance testing, inspection pipes must provide a 2-inch-diameter clear opening and be completely clean, unobstructed, and either dry or filled with water as authorized.
9. After acceptance testing is complete, completely fill the inspection pipes with water.

B. If the rigid cylinder fails to pass through the inspection pipe:

1. Completely fill the inspection pipes in the pile with water immediately.
2. Core a nominal 2-inch-diameter hole through the concrete for the entire length of the pile for each inspection pipe that does not pass the rigid cylinder. Coring must not damage the pile reinforcement.
3. Locate cored holes as close as possible to the inspection pipes they are replacing and no more than 5 inches clear from the reinforcement.

C. Core holes using a double wall core barrel system with a split tube type inner barrel. Coring with a solid type inner barrel is not allowed.

D. Coring methods and equipment must provide intact cores for the entire length of the pile.

E. Photograph and store concrete cores as specified for rock cores in section 49-1.01D(5) of the Caltrans Standard Specifications.

F. The coring operation must be logged by an engineering geologist or civil engineer currently licensed in the State of California and experienced in core logging. Coring logs must comply with the Caltrans's Soil and Rock Logging, Classification, and Presentation Manual for rock cores. Coring logs must include core recovery, rock quality designation of the concrete, locations of breaks, and complete descriptions of inclusions and voids encountered during coring.

G. The VTA evaluates the portion of the pile represented by the cored hole based on the submitted coring logs and concrete cores. If the VTA determines a pile is anomalous based on the coring logs and concrete cores, the pile is rejected.

3.04 CONCRETE PLACEMENT

A. Except for CIDH concrete piles constructed under slurry, construct CIP concrete piles such that the excavation methods and the concrete placement procedures provide for placing the concrete against undisturbed material, casing, or steel shell in a dry or dewatered hole.

B. Concrete must be placed as soon as possible after reinforcing steel installation. Concrete placement must be continuous from the bottom to the top elevation of the shaft. Concrete placement must continue until good quality is evident at the top of the shaft. Concrete must 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. If this condition is encountered, a casing must be used and the hole pumped dry prior to concrete placement.

D. Concrete must not be allowed to fall from a height greater than 8 feet without the use of adjustable length pipes or tubes unless the flow of concrete is directed into the center of the hole and the concrete is not allowed to strike the reinforcement, reinforcement bracing, and other objects in the hole.

E. Vibrate concrete in the upper 15 feet of CIP concrete piles.

F. After placing concrete, cure the temporarily exposed surfaces of the CIP concrete piles under section 51-1.03H of the Caltrans Standard Specifications.

G. Steel shells, casings, and drilled holes must be clean and free of debris before reinforcement and concrete are placed.

H. Provide a suitable light to VTA for inspecting the entire length of the steel shell or drilled hole before placing reinforcement and concrete.

I. The methods used to place the concrete must prevent segregation.

J. Placing Concrete Under Slurry:

1. You may construct CIDH concrete piles 24 inches in diameter or larger by excavating and depositing concrete under slurry.
2. If drill cuttings settle out of the slurry, clean the bottom of the drilled hole after placing reinforcement and before placing concrete in the drilled hole. Verify that the bottom of the drilled hole is clean.

3. Carefully place concrete in a compact, monolithic mass, using a method that prevents washing of the concrete. Do not vibrate the concrete.
4. Placing concrete must be a continuous operation lasting no longer than the time specified for each concrete placing operation at each pile in your pile installation plan.
5. The delivery tube system must consist of one of the following:

    a. Tremie tube or tubes, each of which is at least 10 inches in diameter, fed by 1 or more concrete pumps
    b. One or more concrete pump discharge tubes, each fed by a single concrete pump

6. The delivery tube system must consist of watertight tubes with sufficient rigidity to keep the tube ends always in the mass of concrete placed. If only one delivery tube is used to place the concrete, place the tube near the center of the hole. Multiple tubes must be uniformly spaced in the hole.
7. Internal bracing for the steel reinforcing cage must accommodate the delivery tube system. Do not use tremies for piles without space for a ten-inch-diameter tube.
8. During concrete placement, provide a fully operational standby concrete pump and slurry pump at the Worksite that is adequate to complete the work in the time specified in the pile installation plan.
9. Do not allow concrete to fall into the slurry during concrete placing operations. Cap the delivery tube with a watertight cap, or plug the tube above the slurry level with a good-quality, tight-fitting, moving plug that expels the slurry from the tube as the tube is charged with concrete. The cap or plug must be designed to release as the tube is charged.
10. Extend the pump discharge or tremie tube to the bottom of the hole before charging the tube with concrete. After charging the tube with concrete, induce the flow of concrete through the tube by slightly raising the discharge end.
11. During concrete placement:

    a. Embed the tip of the delivery tube within 6 inches of the bottom of the hole until ten feet of concrete has been placed. Maintain the embedment of the tip at least ten feet below the top surface of the concrete.
    b. Do not rapidly raise or lower the delivery tube.
    c. Maintain the slurry level at a height required to maintain a stable hole, but not less than ten feet above the piezometric head.

12. If the seal is lost or the delivery tube becomes plugged and must be removed:

    a. Withdraw and clean the tube
    b. Cap the tip of the tube to prevent slurry from entering
    c. Restart the operation by pushing the capped tube ten feet into the concrete and then reinitiating the flow of concrete

13. Maintain a log of concrete placement for each drilled hole.
14. If a temporary casing is used, maintain concrete placed under slurry at a level required to maintain a stable hole, but not less than five feet above the bottom of the casing. The withdrawal of the casing must not cause contamination of the concrete with slurry.
15. The equivalent hydrostatic pressure inside the casing must be greater than the hydrostatic pressure on the outside of the casing to prevent intrusion of water, slurry, or soil into the column of freshly placed concrete.
16. Remove scum, laitance, and slurry-contaminated concrete from the top of the pile.
17. Dispose of material resulting from using slurry.
18. If mineral slurry is used, conform to the following requirements:

a. Remove any caked slurry on the sides or bottom of hole before placing reinforcement.
b. If concrete is not placed immediately after placing reinforcement, the reinforcement must be removed and cleaned of slurry, the sides of the drilled hole must be cleaned of caked slurry, and the reinforcement again placed in the hole for concrete placement.

19. If synthetic slurry is used, conform to the following requirements:

a. A manufacturer's representative must provide technical assistance for the use of their material, be at the Worksite before introduction of the synthetic slurry into the drilled hole, and remain at the Worksite until released by VTA.
b. After the manufacturer's representative has been released by VTA, your employee certified by the manufacturer must be present during the construction of the pile under slurry.

3.05 WITHDRAWAL OF TEMPORARY STEEL CASING

A. Remove the temporary casing during concrete placement. Maintain the concrete in the casing at a level required to maintain a stable hole, but not less than 5 feet above the bottom of the casing, to prevent displacement of the concrete by material from outside the casing.

B. If slurry is not used, do not withdraw the temporary casing until the concrete head in the casing is greater than the groundwater head outside of the casing. Maintain this positive concrete head during withdrawal of the casing.

C. You may vibrate or hammer the temporary casing to assist in removal of the casing from the hole, to prevent lifting of the reinforcement, and to prevent concrete contamination.

D. The withdrawal of casings must not leave voids or cause contamination of the concrete with soil or other materials.

3.06 INSTALLATION OF PERMANENT STEEL CASING

A. For permanent steel casings placed in a drilled hole:

1. Casings must be watertight and of sufficient strength to prevent damage and to withstand the loads from installation, drilling and tooling equipment, lateral concrete pressures, and earth pressures.
2. Use spacers to center the casing inside the drilled hole. You may weld spacers to the outside of the casing.
3. Fill voids in the annular space between the casing and the soil with grout.
4. Place grout from the bottom of the casing using grout tubes. Place grout continuously until all voids have been filled and the grout reaches the top of the casing. Free fall of the grout from the top to the bottom of the casing is not allowed.
5. Pump grout into the annular space such that the grout head is maintained uniformly around the casing and no visible evidence of water or air is ejected at the top of the grout.
6. Place grout tubes along the circumference of the casing with a minimum of 4 grout tubes per casing. The spacing of the grout tubes must not exceed 4 feet.
7. Extend grout tubes to within one foot of the bottom of the casing.

B. If VTA lowers the permanent steel casing tip elevation:

1. CIDH concrete pile, including bar reinforcing steel and inspection pipes, must extend to that same elevation
2. Tip elevation of the rock socket must extend to maintain the length of the rock socket into rock as shown

C. The additional work involved in lowering the permanent steel casing tip elevation is change order work.

3.07 CONSTRUCTION JOINT

A. If a construction joint is shown, you must furnish and install a permanent casing. The permanent casing must conform to the following requirements:

1. The permanent casing must be watertight and of sufficient strength to prevent damage and to withstand the loads from installation procedures, drilling and tooling equipment, lateral concrete pressures, and earth pressures.
2. The permanent casing must extend at least 5 feet below the construction joint. If placing casing into rock or a dry hole, the casing must extend at least 2 feet below the construction joint.
3. The permanent casing must not extend above the top of the drilled hole or final grade, whichever is lower.
4. The permanent casing must not increase the diameter of the CIDH concrete pile more than 2 feet.
5. The permanent casing must be installed by impact or vibratory hammers, oscillators, rotators, or by placing in a drilled hole. Casings placed in a drilled hole must comply with section 49-3.02C(6).

3.08 FIELD QUALITY CONTROL AND ASSURANCE

A. Inspections and Tests: The Independent Testing Agency must perform inspections and tests of concrete as specified in Section 03 30 00, Cast-in-Place Concrete.

B. Records and Reports: The Independent Testing Agency must keep a record, on an approved form, for each drilled shaft foundation installed. The Independent Testing Agency must 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.

C. Acceptance Testing:

1. Acceptance testing must be performed by the Independent Testing Agency on CIDH concrete piles, except for piles less than 24 inches in diameter or piles constructed in dry or dewatered holes.
2. The Independent Testing Agency must perform acceptance testing using gamma-gamma logging in accordance with California Test 233 to test the concrete density of the pile for homogeneity.
3. Gamma-Gamma Logging:

    a. The Independent Testing Agency must perform gamma-gamma logging in accordance with California Test 233.
    b. Separate reinforcing steel as necessary to allow the Independent Testing Agency access to the inspection pipes.

c. The Independent Testing Agency must perform the testing and prepare and provide the pile acceptance test report in accordance with California Test 233.
d. During testing, do not perform construction activities within 25 feet of any gamma-gamma logging operation.
e. Anomalies in a pile must be determined in accordance with California Test 233, part 5C. If anomalies in a pile are detected, the pile is rejected.

4. After notification by the Engineer of pile acceptance, fill the inspection pipes and cored holes with grout. Grout must comply with the material requirements specified in this Specification Section. Fill inspection pipes and holes using grout tubes that extend to the bottom of the pipe or hole or into the grout already placed.

D. Rejected Piles:

1. If a pile is rejected:

a. Suspend concrete placement in the remaining piles.
b. Submit a revised pile installation plan.
c. Do not resume concrete placement until the revised pile installation plan is authorized.

2. Allow 30 days for the VTA to determine whether the rejected pile requires mitigation and to provide this information to you. Day one of the 30 days is the first day after the pile acceptance test report has been submitted to VTA.
3. If ordered by the VTA, the Independent Testing Agency must perform crosshole sonic logging to determine the extent of the anomalies identified by gamma-gamma logging and to further evaluate a rejected pile for the presence of anomalies not identified by gamma-gamma logging.
4. If authorized by the Engineer, you may perform additional testing on the rejected pile.
5. The VTA determines whether the rejected pile requires mitigation due to structural, geotechnical, or corrosion concerns. The VTA considers the estimated size and location of the anomaly and potential effects on the design. Allow 20 days for the VTA to provide you with the conclusions of this analysis for developing the mitigation plan. Day one of the 20 days is the first day after the crosshole sonic logging test report has been submitted to VTA.
6. If a rejected pile does not require mitigation, you may repair the pile under an authorized mitigation plan or the amount shown in the table will be deducted for each anomaly up to the maximum total deduction:

Anomaly location	Anomaly deduction ($)		
	D < 4 feet	4 ≤ D < 6	D ≥ 6
Entirely or partially within the upper 2/3 of the pile length	1,000	2,000	4,000
Entirely within the lower 1/3 of the pile length	500	1,000	2,000
Maximum total deduction	2,000	4,000	8,000

Note:
D = Nominal pile diameter

7. If a rejected pile requires mitigation or you elect to repair a rejected pile that does not require mitigation, submit a mitigation plan for the repair, supplementation, or replacement of the rejected pile.

8. If the Engineer determines it is not feasible to use one of ADSC's standard mitigation plans to mitigate the pile, schedule a meeting and meet with the Engineer before submitting a nonstandard mitigation plan.
9. The meeting attendees must include your representatives and the Engineer's representatives involved in the pile mitigation. The purpose of the meeting is to discuss the type of pile mitigation acceptable to the VTA.
10. Provide the meeting facility. The Engineer conducts the meeting.
11. If the Engineer determines it is not feasible to repair the rejected pile, submit a mitigation plan for replacement or supplementation of the rejected pile.

END OF SECTION 31 63 29

ATTACHMENT FOLLOWS

PILE DESIGN DATA FORM

Structure Name: ____

Pile Drilling Contractor or Subcontractor (Pile Drilling By): ____________________

Submitted By: ______________________ Phone No.: ______________ Date: ___________

1 Foundation Testing

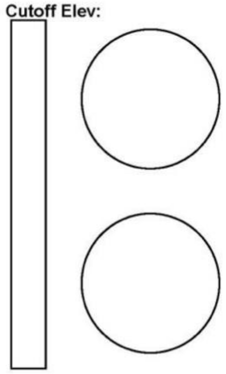
Name:
Phone:
Date:

Anomaly Overview

Testing Performed ☐ GGL ☐ CSL

Shaft Diameter:

Cutoff Elev:



Section A-A

Section B-B

Tip Elev.:

Anomaly Description

Section A-A: ______________________________
____
____

Section B-B: ______________________________
____
____

2 Geotechnical

Name:
Phone:
Date:

Required Nominal Resistance of Shaft (per contract plans)

Compression:________kips Tension:________kips

Lowest Estimated Groundwater Elevation: __________

Remaining Required Nominal Resistance To Be Developed Below Each Anomalous Section:

Section A-A: Compression_________Tension_______kips

Soil and/or Rock Type: _____________

Shaft is geotechnically ☐ Acceptable ☐ Unacceptable

Section B-B: Compression_________Tension_______kips

Soil and/or Rock Type: _____________

Shaft is geotechnically ☐ Acceptable ☐ Unacceptable

Comments:____________________________________
____

3 Structural

Name:
Phone:
Date:

As-Designed Capacity of Shaft

Section A-A: Shear: ________ Moment: _________

Section B-B: Shear: ________ Moment: _________

Maximum Demand of Shaft at Section A-A

Shear: _________ Moment: _________

Shaft is structurally ☐ Acceptable ☐ Unacceptable

Maximum Demand of Shaft at Section B-B

Shear: _________ Moment: _________

Shaft is structurally ☐ Acceptable ☐ Unacceptable

Comments:____________________________________
____

4 Corrosion

Name:
Phone: Date:

Consideration is ☐ Required ☐ Not required

For anomalies between the top of pile and 3 feet below the lowest estimated groundwater level at the site, corrosion results listed in the Geotechnical report are used to assess the need for repair. For situations where results are not available, soil samples may be obtained adjacent to the anomaly and tested in accordance with California Test (CT) 643 (Parts 2, 3 and 4) and if necessary, CT 417 and CT 422 to determine soil corrosivity. For anomalies outside these limits, and where no stray current source can be identified, or for non-corrosive soil conditions, no consideration of corrosion potential is required.

Corrosion Potential at Section A-A: ____________________________________

Corrosion Potential at Section B-B: ____________________________________

5 Construction

Considering parts 2-4 of this form,

Structure Rep.:
Phone: Date:

Sec. A-A is: ☐ Acceptable with Administrative Deduction ☐ Unacceptable, Mitigation is Required

Sec. B-B is: ☐ Acceptable with Administrative Deduction ☐ Unacceptable, Mitigation is Required

Abut/Bent:
Pile:

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SECTION 31 66 17

MECHANICALLY STABILIZED EARTH WALLS

PART 1 - GENERAL

1.01 SUMMARY

A. The scope of work outlined in this Section includes the following items of work, as detailed in these Technical Specifications, as shown on the plans or reasonably implied therefrom and is not limited to the following items:

1. Mechanically stabilized earth (MSE) retaining walls
2. Leveling pads
3. Precast reinforced concrete face panels
4. Soil reinforcement
5. Structure backfill
6. Wall underdrain system
7. Filter fabric
8. Permeable material

1.02 RELATED SECTIONS

A. Section 6.6.2, Submittal, of the Special Conditions

B. Section 7.43, Submittal of Shop Drawings, Product Data and Samples, of the General Conditions

C. Section 03 05 15, Portland Cement Concrete

D. Section 03 11 16, Architectural Cast-in-Place Concrete Forming

E. Section 03 15 15, Elastomeric Bearing Pads

F. Section 03 20 00, Concrete Reinforcing

G. Section 03 30 00, Cast-in-Place Concrete

H. Section 03 35 00, Concrete Finishing

I. Section 03 41 00, Structural Precast Concrete

J. Section 05 17 00, Miscellaneous Metal

K. Section 31 00 00, Earthwork

L. Section 31 23 43, Structure Excavation and Backfill

1.03 REFERENCED STANDARDS

A. American Concrete Institute (ACI):

1.	ACI 318	Building Code Requirements for Structural Concrete

B. ASTM International (ASTM):

1.	ASTM A53/A53M	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
2.	ASTM A370	Standard Test Methods and Definitions for Mechanical Testing of Steel Products
3.	ASTM A1064/1064M	Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
4.	ASTM D1752	Standard Specification for Preformed Sponge Rubber, Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction

C. State of California, Department of Transportation (Caltrans), Standard Specifications 2018:

1.	Section 66	Corrugated Metal Pipe
2.	Section 68	Subsurface Drains
3.	Section 72	Slope Protection

D. State of California, Department of Transportation (Caltrans):

1.	California Test 112	Method for Installation and Use of Embankment Settlement Devices

1.04 DEFINITIONS

A. The term “MSE walls” indicates mechanically stabilized earth walls.

B. The terms “MSE walls,” “mechanically stabilized earth walls,” and “mechanically stabilized embankment” are used interchangeably.

1.05 SUBMITTALS

A. General: Submittals for mechanically stabilized earth walls must be made in accordance with the provisions in Section 6.6.2, Submittal, of the Special Conditions, Section 7.43, Submittal of Shop Drawings, Product Data and Samples, of the General Conditions, and these Technical Specifications.

B. Shop Drawings and Calculations: Submit complete design calculations and Shop Drawings, sealed and signed by an engineer who is currently registered as a civil engineer in the State of California.

1. Shop Drawings must include all details, dimensions, quantities, cross-sections, and any other information necessary to construct the wall at each location and must include, but not be limited to the following items:

    a. An elevation drawing or drawings for each wall.
    b. An elevation or suitable table which must include the existing ground line at the wall face, the elevation at the top of the wall at all horizontal and vertical break points and at least every 50 feet along the face of the wall, all steps in the leveling pads, the designation as to the type of panel, the length of soil reinforcing elements, the distance along the face of the wall to where changes in the length of reinforcing elements occur, and an indication of the final ground line and maximum calculated bearing pressure.

c. A typical cross-section showing the elevation relationship between current and interim (if applicable) ground condition and proposed grades.
d. Design parameters, material notes, and wall construction procedures.
e. A summary of quantities.
f. All panel details must show all dimensions necessary to construct the element, all reinforcing steel in the element, and the location of soil reinforcing connection devices embedded in the panel.
g. Details of the architectural treatment.
h. Details for diverting soil reinforcement around obstructions or to accommodate special features, such as coping.
i. Details for connections between the concrete panel and the soil reinforcement.
j. Specialty details including but not limited to precast coping, slip joint covers, corner panels, and the like.

2. Verify existing ground elevations before submitting Shop Drawings.
3. Shop Drawings and Calculations must be submitted to VTA for review by VTA and the Structural Engineer of Record. Do not order materials, begin fabrication, or begin construction of work related to the submittal until the submittal has been reviewed and stamped by the Structural Engineer of Record with a Shop Drawing stamp marked "Reviewed" or "Make Corrections Noted" and returned to the Contractor by VTA.

C. Certificates of Compliance:

1. Provide Certificates of Compliance for all imported backfill material to be used.
2. Certificates of Compliance must include the name, source and description of materials used and must be signed by the material supplier certifying that each material item complies with, or exceeds the specified requirements.

D. Quality Control Test Reports:

1. Submit results from the proposed button-head wire coupler test.
2. Submit results from each production button-head wire coupler test.

E. Field Construction Manual: Prior to facing panel fabrication, submit a field construction manual for the proposed MSE wall system. This manual must provide step-by-step instructions for construction of the proposed MSE wall system.

F. As-Built Drawings:

1. For as-built drawings common to more than one structure, submit the as-built drawings for each structure.

G. Reinforcement: Submittals must be made in accordance with the requirements of Section 03 20 00, Concrete Reinforcing.

H. Precast Concrete: Submittals must be made in accordance with the requirements of Section 03 41 00, Structural Precast Concrete

1.06 QUALITY CONTROL AND ASSURANCE

A. Codes and Standards: Comply with all Federal, State and local codes and safety regulations.

B. Inspection by VTA and Other Governing and Regulatory Authorities: Allow VTA and other governing and regulatory authorities to perform testing and inspection of materials and practices associated with construction within their jurisdiction on the Worksite during business hours for the purpose of ensuring that the Work is in compliance with the requirements of the plans, these Technical Specifications, and other local, state and federal laws and regulations.

C. Contractor Quality Control:

1. Sampling, Testing and Inspection:

   a. Hire an Independent Testing Agency to perform sampling, testing, and inspections in accordance with the provisions herein and Section 6.26, Quality Assurance and Quality Control Requirements, of the Special Provisions.
   b. Wherever it is specified herein that sampling, testing, or inspection must be performed by the Contractor, it must be understood to mean that said sampling, testing, or inspection must be performed by the Independent Testing Agency.
   c. Cooperate with and notify VTA at least 48 hours in advance of sampling, tests and inspections, being performed by the Independent Testing Agency. VTA may elect to observe these procedures. Provide samples and facilities for inspection to VTA without extra charge if requested.
   d. The Independent Testing Agency must collect samples of materials for testing in accordance with the provisions outlined herein and as directed by VTA.

2. Qualifications of the Independent Testing Agency: Refer to Section 6.26, Quality Assurance and Quality Control Requirements, of the Special Provisions.

D. VTA Quality Assurance:

1. VTA will monitor the implementation of the Contractor's quality control programs through observation, inspection, sampling and testing in accordance with Section 6.26, Quality Assurance and Quality Control Requirements, of the Special Provisions.
2. Failure of VTA to detect work or material which is defective or contrary to these Technical Specifications must not prevent later rejection when such work or material is discovered, nor must it obligate VTA for final acceptance.

1.07 QUALIFICATIONS OF WALL SUPPLIER

A. Acceptable wall suppliers include:

1. The Reinforced Earth Company (Reston, VA)
2. SSL (Scotts Valley, CA)
3. Other suppliers subject to VTA approval

B. The wall supplier must have ten years of experience in designing, manufacturing, and supplying the proposed MSE wall system in the United States, and must have completed five projects in which the proposed wall system has been constructed and designed to support heavy rail loading.

C. All MSE walls must be built in accordance with VTA-approved, Contractor-prepared Design Calculations and Shop Drawings.

1.08 MEASUREMENT AND PAYMENT

A. Measurement: Mechanically Stabilized Earth Walls must be measured by the square foot.

1. Measurement of Mechanically Stabilized Earth Walls must be measured by the area of walls projected on a vertical plane. The vertical height of each section is the difference in elevation on the outer face from the bottom of the lowermost face element to the top of wall profile. The length of the walls must be measured along the face of the wall.

B. Payment: The contract price paid per square foot of Mechanically Stabilized Earth Walls must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing mechanically stabilized earth walls complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefor.

C. Full compensation for furnishing and installing all architectural treatment, earthwork, reinforcing strips, attachment devices, joint materials, elastomeric bearing pads, leveling pad, and wall underdrain system must be considered as included in the bid item for Mechanically Stabilized Earth Walls and no additional compensation will be allowed therefor.

D. Full compensation for incorporating settlement periods and surcharges as specified in these Technical Specifications must be considered as included in the bid item for Mechanically Stabilized Earth Walls and no additional compensation will be allowed therefor.

E. Full compensation for the construction of four settlement platforms at the North Approach embankment and monitoring settlement as specified in these Technical Specifications must be considered as included in the bid item for Mechanically Stabilized Earth Walls and no additional compensation will be allowed therefor.

F. Full compensation for furnishing and installing all bar reinforcing steel for precast reinforced concrete face panels of MSE walls must be considered as included in the bid item for Mechanically Stabilized Earth Walls and no additional compensation will be allowed therefor.

G. Full compensation for constructing preconstruction test panels as specified in these Technical Specifications must be considered as included in the bid item for Mechanically Stabilized Earth Walls and no additional compensation will be allowed therefor.

H. Full compensation for constructing Barrier Slab, including furnishing and installing bar reinforcing steel, steel dowels, and expansion joint filler, must be considered as included in the bid item for Barrier Slab and no additional compensation will be allowed therefor. Attention is directed to Section 03 30 00, Cast-in-Place Concrete, for measurement and payment of Barrier Slab.

PART 2 - PRODUCTS

2.01 MATERIALS

A. General:

1. Concrete panels must comply with Section 03 41 00, Structural Precast Concrete.
2. Concrete reinforcement must comply with Section 03 20 00, Concrete Reinforcing.
3. Earthwork must comply with Section 31 23 43, Structure Excavation and Backfill, and Section 31 00 00, Earthwork.
4. Resin bonded cork for horizontal joints must comply with ASTM D1752, Type II, with a compressive load of at least 100 psi.

5. Pipe pins must comply with ASTM A53/A53M except the zinc coating of actual surface must average at least 2.0 ounces per square foot and no individual specimen may be less than 1.8 ounces per square foot.

B. MSE Wall System:

1. Use only one MSE wall system for all MSE walls. The MSE walls must comply with the requirements specified herein.
2. Only systems having characteristics suitable for this project are specified. Some systems may be proprietary.
3. The MSE wall system must be one of the systems shown in the following table:

MSE wall system	Website	Address	Telephone no.
Reinforced Earth – 5 ft square (Steel strap soil reinforcement with 5 ft square concrete face panels.)	https://www.reinforcedearth.com	THE REINFORCED EARTH COMPANY 23161 MILL CREEK DR STE 315 LAGUNA HILLS CA 92653-7907	(949) 427-3601
Retained Earth (Steel mesh soil reinforcement with 5 ft square concrete face panels.)	https://www.reinforcedearth.com	THE REINFORCED EARTH COMPANY 23161 MILL CREEK DR STE 315 LAGUNA HILLS CA 92653-7907	(949) 427-3601
MSE Plus – 5 ft square (Steel mesh soil reinforcement with 5 ft square concrete face panels.)	http://www.mseplus.com	SSL 4740 SCOTTS VALLEY DR STE E SCOTTS VALLEY CA 95066-4240	(831) 430-9300

C. Face Panels:

1. If architectural treatment is not required, finish exposed surfaces of concrete members as specified for Class 1 surface finish under Section 03 35 00, Concrete Finishing.

D. Structure Backfill:

1. Structure backfill for mechanically stabilized embankment must be free of organic material and substantially free of shale and other soft material of poor durability
2. Structure backfill for mechanically stabilized embankment must not contain slag aggregate or recycled materials such as glass, shredded tires, Portland cement concrete rubble including asphaltic dust, sand, rock, grindings, slabs, and boulders, asphaltic concrete rubble including asphaltic dust, sand, rock, grindings, slabs, and boulders, or other unsuitable material as determined by VTA.
3. For an embankment with metallic soil reinforcement, structure backfill must comply with the requirements shown in the following tables:

Gradation Requirements

Sieve size	Test method	Requirement (percent passing)
6 inch	California Test 202	100
3 inch	California Test 202	78–100
No. 30	California Test 202	0–60
No. 200	California Test 202	0–15

Quality Characteristic Requirements

Quality characteristic	Test method	Requirement
Sand equivalent (min) (See Note A)	California Test 217	12
Plasticity index (max) (See Note A)	California Test 204	6
Minimum resistivity (ohm-cm)	California Test 643	2000
Chlorides (ppm)	California Test 422	< 250
Sulfates (ppm)	California Test 417	< 500
pH	California Test 643	5.5–10.0

Note A: Does not apply if 12 percent or less passes the no. 200 sieve and 50 percent or less passes the no. 4 sieve.

E. Permeable Material:

1. Permeable material must consist of hard, durable, clean sand, gravel, or crushed stone and must be free from organic material, clay balls, or other deleterious substances.
2. Permeable material must have a durability index of not less than 40.
3. The percentage composition by weight of permeable material in place must comply with the gradation requirements shown in the following table:

Sieve size	Percentage passing
2 inches	100
1-1/2 inches	95–100
3/4 inch	50–100
1/2 inch	--
3/8 inch	15–55
No. 4	0–25
No. 8	0–5
No. 200	0–3

4. Permeable material for an embankment with metallic soil reinforcement must comply with the requirements shown in the following table:

Quality Characteristic Requirements

Quality characteristic	Test method	Requirement
Minimum resistivity (ohm-cm)	California Test 643	2,000
Chlorides (max, ppm)	California Test 422	250
Sulfates (max, ppm)	California Test 417	500
pH	California Test 643	5.5–10.0

F. Soil Reinforcement:

1. Soil reinforcement, connecting elements, and other steel components in contact with the earth must be galvanized in accordance with the requirements for galvanized miscellaneous metals specified in Section 05 17 00, Miscellaneous Metal.
2. Threaded ends of inspection wires for metallic soil reinforcement may be formed before or after galvanizing. Coat the final four inches of the wire with two applications of organic zinc-rich primer. Encase the threaded end with a waterproof vinyl enclosure secured with a nylon tie. If the threaded end is galvanized after threading, clean the threads before painting.
3. Steel wire must comply with the specifications for plain wire reinforcement in ASTM A1064/A1064M. Welded wire reinforcement must comply with the specifications for plain wire welded wire reinforcement in ASTM A1064/1064M.
4. For button-headed wires:

    a. Buttons must be cold formed symmetrically about the axes of the wires.
    b. Buttons must develop the minimum guaranteed ultimate tensile strength of the wire.
    c. Do not use a cold-forming process that causes indentations in the wire.
    d. Button heads must not contain wide open splits, more than two splits per head, or splits nonparallel to the axis of the wire.

5. Steel wire reinforcement hooks and bends must comply with ACI 318.
6. Couplers at wire reinforcement connections must be seamless steel sleeves applied over the button-head wires. Couplers must develop the wire minimum tensile strength with a total slip of at most 3/16 inch.
7. Splice welded wire reinforcement along its length with mechanical couplers that develop the minimum tensile strength of the wire.

G. Filter Fabric:

1. Filter fabric must be Class A.
2. Adhesive for bonding filter fabric to concrete panels must be commercial grade.

H. Wall Underdrain System

1. Corrugated steel pipe must comply with Section 66, “Corrugated Metal Pipe,” of the Caltrans Standard Specifications.
2. Perforated pipe underdrains and underdrain outlets and risers must comply with Section 68-2, “Underdrains,” of the Caltrans Standard Specifications. Perforated pipe must be steel unless perforated plastic pipe is shown.
3. Rock for rock slope protection at drain pipe outlets must be small-rock slope protection and must comply with the gradation specified for 7-inch-thick layer in Section 72-4.02 of the Caltrans Standard Specifications.

I. Leveling Pads:

1. Concrete leveling pads must be constructed with minor concrete. Refer to Section 03 05 15, Portland Cement Concrete, for requirements for minor concrete.

J. Elastomeric Bearing Pads: Elastomeric bearing pads must conform to the requirements of Section 03 15 15, Elastomeric Bearing Pads.

2.02 SOURCE QUALITY CONTROL

A. The Independent Testing Agency must perform tension and slip tests on the proposed button-head wire soil reinforcement and coupler connection. The Independent Testing Agency must test six connection test samples. Test samples must consist of two 24-inches long button-head wires connected by a swaged coupler. Testing must be performed by a laboratory authorized by the VTA.

1. Coupler test samples must comply with the minimum tensile specifications for plain wire in ASTM A1064A/1064M.
2. Total wire slip must be at most 3/16 inch when tested as specified for tension testing of round wire test samples under ASTM A370.
3. If any test samples fail, revise the connection and retest. Do not start face panel installation until tension and slip test results are accepted.

PART 3 - EXECUTION

3.01 GENERAL

A. Water for earthwork or for dust control within 500 feet of structures with metallic soil reinforcement must comply with the specifications for water in reinforced concrete in Section 03 05 15, Portland Cement Concrete.

B. Protect the unthreaded portion of the galvanized inspection wire from damage.

3.02 PRECONSTRUCTION TEST PANELS

A. Facing Panels: At least 30 days before the start of casting facing panels, Contractor must construct a full scale wall panel for each facing panel type, complete with all handling and fastening features, for inspection and approval by VTA. The concrete must be placed in the test panels, the finishes constructed, and the construction procedure adjusted, until a final finish is produced that complies with the Plans and these Technical Specifications, as determined by VTA. If ordered by VTA, additional test panels must be constructed and finished until a satisfactory finish is obtained. The test panels approved by VTA must then be the standard of comparison for the appearance of the production facing panels. The approved panels may be used in the work.

B. Concrete coping and barrier slab: At least 30 days before start of construction of concrete coping, Contractor must construct test panels at least two feet by six inches in size for inspection and approval by VTA. The concrete must be placed in the test panels, the finishes constructed and the construction procedure adjusted, until a final finish is produced that complies with the Plans and these Technical Specifications as determined by VTA. If ordered by VTA, additional test panels must be constructed and finished until a satisfactory finish is obtained at no additional cost to the VTA.

3.03 CONSTRUCTION

A. Where shown, construct the MSE wall to accommodate wall-mounted lighting and drainpipes, and panels for future drainage inlets.

B. The top of wall profile must conform to the profile shown. The bottom of wall elevations must be at or below the elevations shown. Use a minimum height and length of wall adequate for the loading and site conditions described.

C. The length of soil reinforcement must not be less than that shown.

D. The coping lip or barrier slab lip must cover the top of face panels at least seven inches.

E. Check vertical and horizontal alignment at each course during erection.

F. Include a drainage system where shown.

G. Settlement Periods and Surcharges:

1. Settlement periods and surcharges are required for roadway embankments at the earth retaining structures as shown in the following table:

North Approach earth retaining structure number	Surcharge height (feet)	Settlement period (days)
Retaining Wall No. 2 (MSE Wall)	0.0	60
Retaining Wall No. 4 (MSE Wall)	0.0	60

2. If an embankment settlement period is specified, construct the embankment to at least the grading plane and to the limits described for:

   a. Distance of at least 150 feet measured parallel to the centerline of the roadway from each bridge abutment
   b. Entire length of a retaining wall and a width of at least 30 feet from the face of the wall

3. If a surcharge is specified, place the surcharge in uniform layers. Compact the surcharge by routing the grading equipment across the full width.
4. Prevent the embankment and any surcharge from encroaching upon the traveled way or existing improvements.
5. The settlement period starts after the embankment and any specified surcharge construction is complete.
6. Install four settlement platforms along the North Approach embankment, evenly spaced along the length of the North Approach embankment. Monitor settlement in accordance with California Test 112.

   a. If additional settlement platforms are ordered by VTA, install additional settlement platforms. The installation of additional settlement platforms is change order work.

7. The surcharge must remain in place until the end of the specified settlement period or as ordered.
8. Before the end of the settlement period, do not excavate for abutments, wingwalls, or retaining wall footings.

9. Before the end of the settlement period, do not drive or drill holes for foundation piles.
10. Remove any surcharge material.
11. Remove surcharge material above the grading plane. Compact the embankment below the grading plane before placing the subsequent layers of subbase or base.

H. General Earthwork:

1. Grade the foundation level for a width equal to the length of soil reinforcement elements plus one foot or as shown. Compact foundation material to a relative compaction of at least 95 percent. Start wall construction activities after VTA accepts the compacted foundation area.
2. If ordered, remove unsuitable material. This work is change order work.
3. Place structure backfill simultaneously with erection of facing panels. Place and compact material without distorting soil reinforcement or displacing facing panels. Place structure backfill at the front of the wall before backfilling more than 15 feet above the bottom of the lowermost face element.
4. If a mechanically stabilized embankment with soil reinforcement is to be constructed on an embankment, compact embankment material to a relative compaction of at least 95 percent within the limits established by inclined planes sloping 1.5:1 (horizontal : vertical) from lines one foot outside the bottom limits of the mechanically stabilized embankment, including any permeable material.
5. Start placing and compacting structure backfill one foot from the back face of wall panels and progress toward the free end of the soil reinforcement. Operate compaction equipment parallel to the wall facing. Place and compact the remaining width of backfill behind wall panels after covering the soil reinforcement to a depth of six inches.
6. Do not use sheepsfoot or grid-type rollers within the limits of soil reinforcement. Use hand-held or hand-guided compacting equipment within three feet of facing panels.
7. Place structure backfill at each level of soil reinforcement to a plane two inches above the elevation of the soil reinforcement connection, starting three feet from the back of the face panel and extending for at least the remaining length of soil reinforcement. Complete this grading before placing the next layer of soil reinforcement.
8. Place permeable material and filter fabric when placing structure backfill. Place permeable material in layers less than two feet thick. Compaction of permeable material for the drainage system outside the limits of soil reinforcement is not required. Do not operate equipment directly on the permeable material or filter fabric. If a sloped layer of permeable material is placed to facilitate the work or to satisfy safety considerations, the vertical limits of the permeable material must remain unchanged and the thickness of the layer of permeable material is measured normal to the slope.
9. Grade backfill to drain away from the wall face at the end of each work shift. Use berms or ditches to direct runoff away from the wall site. Do not allow surface runoff from adjacent areas to enter the wall site.

I. Soil Reinforcement:

1. Tension soil reinforcement in the direction perpendicular to the wall face. Remove slack in the connection and the soil reinforcement. Secure soil reinforcement in place before and during compaction.
2. Swage wire reinforcement couplers with a hydraulic press.
3. Cover soil reinforcement with structure backfill during the same work shift that it is placed.
4. Do not operate construction equipment directly on soil reinforcement. Maintain a layer of structure backfill at least six inches thick between soil reinforcement and any construction equipment.

5. Place the top level of soil reinforcement parallel to the top of the concrete panel, at least three inches below the bottom of either the barrier slab lip or the concrete gutter behind the coping, and at least five inches below the top edge of the concrete panel.

J. Face Panels:

1. Vertical and horizontal panel alignment offset must not exceed 3/4 inch when measured along a 10-foot straightedge. The offset in any panel joint must not exceed 3/4 inch.
2. After placing backfill two feet above inspection elements, dry pack voids in face panels with mortar in accordance with Section 03 30 00, Cast-in-Place Concrete.

   a. Mortar must be composed of cement, sand, and water. Materials for mortar must comply with Section 03 05 15, Portland Cement Concrete.
   b. The proportion of cementitious material to sand must be such that the mortar achieves a 28 day compressive strength of 1,000 to 1,500 pounds per square inch.
   c. Mortar must contain only enough water to allow placing and packing.
   d. Sand particles must be no larger than one half the size of the recess or space in which the mortar is to be placed.

K. Filter Fabric

1. Immediately before placing filter fabric, the subgrade to receive filter fabric must be free of loose or extraneous material and sharp objects that may damage the filter fabric.
2. Concrete panel surfaces to receive filter fabric must be dry and thoroughly cleaned.
3. Handle and place filter fabric under the manufacturer's instructions. Stretch, align, and place fabric without wrinkling.
4. Adjacent borders of filter fabric must be stitched or overlapped. Overlap rolls 12 to 18 inches. Place the preceding roll over the following roll in the direction the material is being spread. Stitch fabric using yarn of a contrasting color. Yarn size and composition must comply with the filter fabric manufacturer's instructions. Use five to seven stitches per inch of seam.
5. Repair damaged filter fabric by placing a piece of filter fabric large enough to cover the damaged area and provide at least a 12-inch overlap.
6. Do not operate equipment, including vehicles, directly on filter fabric. Maintain at least six inches of permeable material between filter fabric and equipment during spreading of permeable material. Where structure backfill is to be placed on filter fabric, maintain at least 18 inches of structure backfill material between filter fabric and equipment during placement.

L. Leveling Pads

1. Place concrete for leveling pads at least 24 hours before erecting face panels.

3.04 FIELD QUALITY CONTROL

A. The Independent Testing Agency must perform tension and slip testing on production button-head wire and coupler connections during wall construction. The Independent Testing Agency must test four connection test samples for each lot of 500 mat wire connections installed. If two or more test samples fail, the entire represented lot is rejected. If one test sample fails to comply with specified criteria, the Independent Testing Agency must test an additional four test samples. If any of these additional samples fail, the entire represented lot is rejected.

B. The Contractor must retain a qualified representative of the MSE wall system manufacturer to provide full time inspection during erection and backfill of the first ten vertical feet of the entire length of the wall. The representative must be available during the remaining installation. The representative must not be your employee.

END OF SECTION 31 66 17

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SECTION 31 92 13

LANDSCAPE SOIL PREPARATION

PART 1 - GENERAL

1.01 SUMMARY

A. This section includes requirements for landscape soil preparation, including, but not necessarily limited to, the following: topsoil placement, organic amendment and fertilizer placement, and finish grading. See section 33 43 04 for Biofiltration soil mix.

1.02 QUALITY CONTROL

A. Reviews: Contractor must specifically request at least two working days in advance the following reviews prior to progressing with the work:
1. Completion of rough grading
2. Verification of amendment incorporation depths
3. Finish grade

B. Certification: Written certificates stating quantity, type, and composition, weight and origin for all amendments and chemicals must be delivered to the Engineer before the material is used on the site.

C. Soil Samples: Contractor must provide a one-quart sample of the native or import topsoil from each median to Waypoint Analytical, Inc. or equivalent testing laboratory, for their testing for conformance to this specification. Import topsoil shall be provided in all areas where new landscaped medians are being installed where roadway pavement currently exists. No material shall be delivered to the site, graded on-site, or otherwise modified until the Engineer approves the material. All testing costs must be paid for by the Contractor. In addition, a five-gallon representative sample of native soil must be supplied to the testing laboratory from areas previously covered by paving for contamination testing. Contamination testing requires four to five weeks. Contractor must allow for sufficient time for such testing prior to construction. Testing costs for the initial samples and costs for any additional samples due to non-compliance must be paid for by the Contractor.

D. Amendment Samples: Contractor must provide a one-quart sample of each proposed amendment to Waypoint Analytical, Inc. or equivalent testing laboratory, for their testing for conformance to this specification. No material shall be delivered to the site until the Engineer approves the samples. Testing costs must be paid for by the Contractor.

E. Planting Areas: All areas to be planted, whether in container stock, flats, or otherwise, are defined as planting areas in these documents.

1.03 MEASUREMENT AND PAYMENT

A. Measurement: Landscape Soil Preparation must be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Landscape Soil Preparation must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Landscape Soil Preparation complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefore

PART 2 - PRODUCTS

2.01 MATERIALS

A. Native Topsoil: Must be the existing surface layer of soil on site. This layer typically will be a different color and texture than the subsoil, and may be of varying thicknesses. The Contractor must be responsible for reviewing the area limits and depths of native topsoil on site with the Engineer.

B. Import Topsoil: Must be a homogeneous mineral soil classified as sandy loam, or fine sand. Particle size data must be based upon standard USDA methodology. Of the material falling in the sand category, a minimum of 80% must fall in the fine sand range .05 - 5mm. Gravel content greater than 2.0mm must be less than 15%. Import topsoil must not contain more silt and clay than the on-site native soil. The sum of silt plus clay must be less than 25%; the soil must be nonsaline as determined on the saturation extract. Salinity must not exceed 3.0 mmhos/cm, boron must not exceed 1.0 ppm and the sodium absorption ratio (SAR) must not exceed 6.0. Soil reaction as determined on a saturated paste must fall between 5.5 and 7.5. The soil must be free of organic herbicides, or other growth-restricting chemicals. Contamination may be tested by greenhouse trials using rye grass and radish as test crops using the proposed import soil as substrate. These trials require four to five weeks for completion.

C. Fertilizer: Must be determined from soils analysis results. For purposes of bidding only, assume the use of 6-20-20 commercial fertilizer, 20-10-5 planting tablets by Agriform International Chemicals, Inc., and iron sulfate.

D. Organic Amendment: Must be BFI super-humus compost or approved equal.

1. BFI Super Humus Compost must conform to:

a) Gradation: A minimum of 90% of the material by weight must pass a 1/2” screen. Material passing the 1/2” screen must meet the following criteria.

Percent Passing	Sieve Designation
85-100	9.51 mm (3/8”)
50-80	2.38 (No.8)
0-40	500 micron (No.35)

b) Organic Content: A minimum of 50% based on dry weight and determined by ash method. A minimum of 250 lbs. organic matter per cubic yard of compost.

c) Carbon to Nitrogen Ratio: Maximum 35:1 if material is claimed to be nitrogen stabilized.

d) Soluble Salts: Soluble nutrients typically account for most of the salinity levels but sodium should account for less than 25% of the total. To avoid a leaching requirement, the addition of the compost must result in a final ECe of the amended soil of less than 4.0 ds/m @ 25 degrees C. as determined in a saturation extract. Use the following table to determine the maximum allowable ECe (ds/m of saturation extract) of compost at desired use rate and allowable ECe increase.

e) Moisture Content: 35-60%.

f) Contaminants: The compost must be free of contaminants such as glass, metal and visible plastic.

g) Maturity: Physical characteristics suggestive of maturity include:

Color: dark brown to black

Odor: acceptable = none, soil like, musty or moldy
unacceptable = sour, ammonia or putrid

h) Particle Characterization: identifiable wood pieces are acceptable but the balance of material shall be soil-like without recognizable grass or leaves.

E. Pot Soil Mix for Above Grade Planters at Eastridge Station: Must be a pre-mix planter mix, if tested and approved by the Engineer, composed of fine sand, untreated fir bark, spaghnum peat moss, and fertilizers as follows:

1. Sand:

Percent passing sieve	Sieve size
100	No. 4
95-100	No. 10
90-100	No. 18
65-100	No. 35
0-50	No. 60
0-20	No 140
0-10	No. 270
Salinity (ECe x 10^3)	Nil – 3.0
Boron in saturation extract	Nil – 1.0 ppm
SAR	Nil – 6.0

2. Fir Bark:

Percent passing sieve	Sieve size
100	3/8”0
95-100	1/4”
75-100	No. 8
0-30	No. 35
Dry bulk density	450 – 580 lbs./cu. yd
Organic content (dry weight basis)	94% - 100%
Fertilizer:	
Urea formaldehyde	38-0-0
Single superphosphate	0-20-0
Potassium nitrate	13-0-44
Dolomite lime Kaiser	65 AG or equal
Gypsum	---

3. Sphagnum Peat Moss:

Percent passing sieve	Sieve size
95-100	3/8”
0-40	No. 35
Organic content (dry weight basis)	95% - 100%
Salinity (ECe x 10^3)	Nil – 3.0
Chemical p.H.	3.0 – 4.5

Nitrogen (dry weight basis)	0.6 – 3.0%

PART 3 - EXECUTION

3.01 LIMITS AND GRADES

A. Grade Review: Prior to commencing soil preparation operations, Contractor must request a review by the Engineer to verify specified limits and grades of work completed to date and soil preparation work to commence. Contractor must complete the rough grading as necessary to round the top and toe of all slopes, providing naturalized contouring to integrate newly graded areas with the natural topography. Finish grading under this section must be completed in accordance with the grades indicated on the civil drawings.

3.02 STRIPPING AND STOCKPILING OF EXISTING TOPSOIL

A. Excavation Areas: The native topsoil must be stripped and stockpiled on-site in sufficient quantities to provide a six-inch layer throughout all planting areas. Topsoil to be stripped and stockpiled must be taken from the surface layer after all organic litter and foreign debris has been removed and properly disposed.

B. Existing Grade Unchanged: In those areas where grades are not proposed to be modified (areas of no excavation or fill) the native topsoil must be left in place. All debris, as well as all rocks over 0.75 inches in diameter, must be removed from the surface of planting areas.

3.03 TOPSOIL PLACEMENT

A. Topsoil Incorporation: After all planting areas have been excavated, they must be ripped to a depth of ten (10”) inches. Next, a three-inch layer of topsoil must be uniformly distributed over these areas and thoroughly incorporated into the top six inches of subsoil by ripping, scraping, or tilling to mix the subsoil with the topsoil into a homogeneous mixture. The remaining layer of topsoil must then be uniformly distributed in the planting areas and compacted in place to 85% compaction. The total depth of topsoil to be placed must be as indicated on the drawings.

B. Existing Topsoil to Remain: In those planting areas where native topsoil is to be left in place, cross rip to a depth of ten inches. Then incorporate the amendments to a homogeneously blended soil depth of six inches.

3.04 ORGANIC AMENDMENT AND FERTILIZER INCORPORATION

A. Materials and Rates: Materials determined from the soils test must be uniformly distributed throughout all irrigated planting areas and incorporated to a homogeneously blended soil depth of six inches. Assume per 1000 square feet:

5 cubic yards organic amendment
7 pounds Ammonium Phosphate (16-20-0)
7 pounds Potassium sulfate (0-0-50)
20 pounds soil sulfur
45 pounds Gypsum (Calcium Sulfate)

3.05 PLANT PITS

A. Plant Pit Preparation: Plant pits must have their sides and bottoms loosened or otherwise broken to prevent glazed or compacted surfaces, and must be as shown on the planting detail.

3.06 BACKFILL

A. Backfill Material and Placement: Only unamended soil must be used beneath the root ball; cultivate bottom of plant pit to improve porosity. Backfill around sides of rootball must be the amended soil taken from adjacent prepared areas. Spread material excavated from plant pits onto adjacent areas as replacement. Should additional backfill be necessary, a mixture of one-third organic amendment/fertilizer mix and two-thirds topsoil may be used.

3.07 PLANT TABLETS

A. Tablet Quantities: All container plants must receive plant tablets as follows:

five-gallon plants	five 21-gram tablets
24 inch box trees	eighteen 21-gram tablets

Space the tablets evenly around the root ball halfway up backfill touching side of root ball. Engineer may require excavation of up to 5% of all plants selected at random for conformance review.

3.08 POT MIX

A. Mix Quantities: Contractor must pre-mix and install the following mix at 85% compaction in all pots:

0.5 cu. yd.	fine sand
0.15 cu. yd.	spaghnum peat moss
0.35 cu. yd.	raw fir bark
2 lbs.	urea formaldehyde
3 lbs.	single superphosphate
1 lb.	potassium nitrate
10 lbs.	dolomite lime
3 lbs.	gypsum

Prior to placement of this mixture, Contractor must deliver and have tested a one-quart sample to verify degree of compliance. No mix must be installed until tested by the soils laboratory and approved for installation by the Engineer.

3.09 FINISH GRADING

A. Grading Operations: Contractor must finish grade all irrigated planting areas unless otherwise noted, and must remove all rocks and clods over one cubic inch to a depth of one inch below finish grade. All areas must be smooth and uniformly graded. All erosion damage during the construction period must be repaired by the Contractor.

B. Finish Grades: Unless otherwise noted, all soil finish grades must be one inch below finish grade of walks, pavements, and curbs.

END OF SECTION 31 92 13

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SECTION 32 01 16.71

COLD MILLING ASPHALT PAVEMENT

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for performing cold milling of asphalt pavement.

1.02 RELATED SECTIONS

A. Site Demolition and removal of other roadway facilities is specified in Section 02 41 00, Demolition.

1.03 REFERENCED STANDARDS

A. State of California, Department of Transportation (Caltrans), Standard Specifications 2018:

1. Section 39, Asphalt Concrete

1.04 MEASUREMENT AND PAYMENT

A. Measurement: Only items listed in Bid List will be measured for payment.

1. 2" Grind shall be measured by the Square Yard.
2. 4" Grind shall be measured by the Square Yard.
3. Conform Grind shall be measured by the Square Yard.

B. Payment:

1. The contract price paid per Square Yard for 2" Grind shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in grinding asphalt complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.
2. The contract price paid per Square Yard for 4" Grind shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in grinding asphalt complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.
3. The contract price paid per Square Yard for Conform Grind shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in conform grinding asphalt complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

C. Full compensation for providing Wedge Grind at existing pavement conform shall be considered as included in the bid item for asphalt paving and no additional compensation will be allowed therefore.

PART 2 – PRODUCTS

None

PART 3 – EXECUTION

3.01 PERFORMANCE

A. Perform cold planing of asphalt concrete in accordance with Section 39, Asphalt Concrete, of the Caltrans Standard Specifications. Coordinate with requirements of Section 02 41 00, Demolition.

END OF SECTION 32 01 16.71

SECTION 32 01 90

LANDSCAPE MAINTENANCE

PART 1 - GENERAL

1.01 SUMMARY

A. This section includes requirements for landscape maintenance.

1. Work in this section includes the growing and maintenance operations necessary to establish the newly planted groundcovers, shrubs, trees, and other plantings; to provide insect and disease control, and to maintain the irrigation system, and related construction elements.

1.02 SUBMITTALS

A. Soil Testing: Contractor must collect one (1) one-quart sample from each median in the container planting areas of the in-place topsoil 20 days after completion of planting and submit to Waypoint Analytical, Inc. or approved equal, for maintenance period fertilizer recommendation. Test results must be made available to the Engineer. Sample must be a representative composite taken from several planting areas. Cost of soil test must be paid for by the Contractor.

B. Herbicide/Fungicide/Insecticide: Submit a written recommendation from a State of California appropriately licensed individual along with complete product data from proposed manufacturer, for review by the Engineer.

1.03 MEASUREMENT AND PAYMENT

A. Measurement: Landscape Maintenance must be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Landscape Maintenance must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Landscape Maintenance complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefore

PART 2 - PRODUCTS

2.01 MATERIALS

A. Fertilizer: Used during the course of the maintenance period must be determined by soils test required under Part 1 of this Section. For bidding purposes only, assume the use of ammonium sulfate (21-0-0) at 5 lbs. per 1000 SF, minimum of two applications.

B. Water: During the course of construction and maintenance period water must be paid for by the Contractor.

C. Herbicide/Fungicide/Insecticide: Must be a commercially available chemical recommended for this project and these plantings by a State of California appropriately licensed individual. The licensed individual must review all planting, including but not limited to seed, sod, groundcovers, shrubs, and trees, the types and extent of soil preparation, the irrigation systems, drainage patterns, and other project characteristics to verify type, compatibility, and recommend the appropriate chemical(s) for use. Contractor must be responsible for all overspray, spreading, runoff, plant health, and other impacts from the use of the chemical(s).

PART 3 - EXECUTION

3.01 TIME LIMITS: The maintenance period must commence from the date of substantial completion of planting as defined in paragraph 3.6 below, and extend for a ninety (90) calendar day period thereafter, or until the acceptance of Final Completion.

3.02 FERTILIZER APPLICATION: Fertilizer(s) must be applied per Waypoint Analytical, Inc. or approved equal recommendations. For bidding purposes, assume initial application to be four weeks after planting and subsequent applications to be at 45-day intervals.

3.03 HERBICIDE APPLICATION: Herbicide must not be used until all plant material has been planted a minimum of 20-days. All planting areas must be kept weed-free by non-herbicide methods during this time period. Herbicide must not be applied to any areas that are or have been seeded. Contractor must apply the material in conformance with the written recommendations of the State appropriately licensed individual.

3.04 BASIC REQUIREMENTS: All planting areas must be kept weed-free at all times during the maintenance period. All pest and disease control must be the Contractor’s responsibility. All planting areas must be kept at optimum moisture for plant growth. Settlement of soil and plants and soil erosion must be repaired and areas replanted as required. Dying or deficient plants must be replaced as soon as they become apparent.

3.05 VTA’S RESPONSIBILITY: Work installed under this contract that is damaged or stolen prior to Substantial Completion must be repaired or replaced by the Contractor without cost to VTA. After Substantial Completion and through the maintenance period, these damages and similar factors such as extensive litter, abuse and defacement must be VTA’s responsibility to repair or replace and must not be a part of this contract. No planting must be guaranteed beyond the maintenance period, except as to conformance to specified species and variety, and except as to conditions specified under "Root Systems" of Section 32 93 00, Planting.

3.06 SUBSTANTIAL COMPLETION: Must be deemed as the time all major plantings, including groundcover, are installed, and when all other work is satisfactorily completed (with the exception of minor items to be completed as noted upon a checklist compiled by the Engineer). Maintenance period must not commence until work is deemed substantially complete by the Engineer.

3.07 FINAL REVIEW: Contractor must request a final review of the project at least five days in advance of the proposed date. Failure to request this notice must automatically extend the date of completion. The maintenance period will continue until project is deemed complete.

END OF SECTION 32 01 90

SECTION 32 11 23

AGGREGATE BASE COURSES

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for placing aggregate base courses.

1.02 RELATED SECTIONS

A. Section 01 78 39, Project Record Documents

B. Section 31 34 19, Geosynthetic Soil Reinforcement

C. Section 32 12 16, Asphalt Paving, for hot mix asphalt paving

1.03 REFERENCED STANDARDS

A. American Society for Testing and Materials (ASTM):

1. ASTM D1557 Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort

B. City of San Jose, Department of Public Works, Standard Specifications July 1992.

C. County of Santa Clara, Roads & Airports Department, Standard Specifications May 2000, and Standard Specifications Amendments January 7, 2011

D. State of California, Department of Transportation (Caltrans), Standard Specifications 2018:

1. Section 26, Aggregate Bases.

E. County of Santa Clara, Roads & Airports Department, Standard Specifications May 2000, and Standard Specifications Amendments January 7, 2011

1.04 SUBMITTALS

A. General: Refer to Special Conditions for submittal requirements and procedures.

B. Product Data: Submit source, gradation, R-value, sand equivalent, and durability for each type of proposed base course material.

C. Test Reports: Submit plant and field test reports as specified in Articles 2.03 and 3.05 herein.

D. 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.

1.05 MEASUREMENT AND PAYMENT

A. Measurement:

1. Aggregate Base Class 2 shall be measured by the Cubic Yard.

B. Payment:

1. The contract price paid per Cubic Yard for Aggregate Base Class 2 shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in placing aggregate base complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

C. Full compensation for providing aggregate base underneath curbs, curbs and gutters, sidewalk, driveways, maintenance vehicle pullouts, valley gutters, headers and curb ramps shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 – PRODUCTS

2.01 AGGREGATE BASE CLASS 2

A. Aggregate Base for roadway pavement shall be Class 2 and conform to requirements of Section 26, Aggregate Bases, of the Caltrans Standard Specifications.

2.02 AGGREGATE BASE CLASS 3

A. Aggregate Base underneath curbs, curbs and gutters, sidewalk, driveways, valley gutters, and curb ramps in City of San Jose jurisdiction shall be Class 3 and conform to requirements of Section 26, Aggregate Bases, of the City Standard Specifications.

B. Aggregate Base underneath curbs, curbs and gutters, sidewalk, driveways, maintenance vehicle pullouts, valley gutters, and curb ramps in County of Santa Clara jurisdiction shall be Class 3 and conform to requirements of Section 26, Aggregate Bases, of the County Standard Specifications.

2.03 SOURCE QUALITY CONTROL

A. The Contractor shall perform sampling and tests of the aggregate base material in accordance with Section 26, Aggregate Bases, of the Caltrans Standard Specifications to determine compliance with specified requirements.

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 subgrade or subbase and compacted in accordance with Section 26, Aggregate Bases, 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 6 inches.

C. All compaction expressed in percentages in this section refers to the maximum dry density as determined by ASTM D1557.

D. If shown, place geosynthetic materials in accordance with Section 31 34 19, Geosynthetic Soil Reinforcement, or Hot Mix Asphalt in accordance with Section 32 12 16, Asphalt Paving.

3.03 SPREADING OF MATERIAL

A. Spread material in accordance with Section 26, Aggregate Bases, of the Caltrans Standard Specifications.

3.04 COMPACTING

A. Compact material in accordance with Section 26, Aggregate Bases, of the Caltrans Standard Specifications.

3.05 FIELD QUALITY CONTROL

A. Contractor shall perform field tests on material in accordance with Contractor's approved testing plan, or in accordance with Section 26, Aggregate Bases, of the Caltrans Standard Specifications.

END OF SECTION 32 11 23

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SECTION 32 12 16

ASPHALT PAVING

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for placing hot mix asphalt of various types.

1.02 RELATED SECTIONS

A. Section 01 78 39, Project Record Documents

B. Section 31 00 00, Earthwork for subgrade preparation

C. Section 31 34 19, Geosynthetic Soil Reinforcement

D. Section 32 11 23, Aggregate Base Courses

E. Section 33 05 10, Adjust Frame and Cover to Grade, for adjustment of utilities to grade

1.03 REFERENCED STANDARDS

A. City of San Jose, Department of Public Works, Standard Specifications July 1992.

1. Section 30, Deep Lift Asphalt Base
2. Section 39, Asphalt Concrete.

B. County of Santa Clara, Roads & Airports Department, Standard Specifications May 2000, and Standard Specifications Amendments January 7, 2011

C. State of California, Department of Transportation (Caltrans), Standard Specifications 2018:

1. Section 39, Asphalt Concrete.
2. Section 92, Asphalt Binders
3. Section 94, Asphaltic Emulsions

1.04 SUBMITTALS

A. General: Refer to Special Conditions for submittal requirements and procedures.

B. Mix Design: Submit proposed Job Mix Formula for each asphalt 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.

D. 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.

1.05 MEASUREMENT AND PAYMENT

A. Measurement:

1. Hot Mix Asphalt (Type A) shall be measured by the Ton.
2. RHMA-G shall be measured by the Ton.

B. Payment:

1. The contract price paid per Ton for Hot Mix Asphalt (Type A) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in placing hot mix asphalt complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

2. The contract price paid per Ton for RHMA-G shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in placing rubberized hot mix asphalt complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

C. Full compensation for placing temporary asphalt transitions and backfill shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

D. Full compensation for providing asphalt for traffic control and staging shall be considered as included in the bid item for TRAFFIC CONTROL and no additional compensation will be allowed therefore.

PART 2 – PRODUCTS

2.01 HOT MIX ASPHALT

A. Hot Mix Asphalt shall be designed and installed by the Standard Construction Process.

B. Hot Mix Asphalt shall be Type A and conform to requirements of Section 39, Asphalt Concrete, of the Caltrans Standard Specifications.

C. Asphalt Binder shall be PG 64-10 and conform to requirements of Section 92, Asphalt Binders, of the Caltrans Standard Specifications.

D. Aggregate shall conform to the following:

1. ½” Maximum, for 2” overlay and final lift within City of San Jose jurisdiction conforming to requirements of Section 39, Asphalt Concrete, of the City Standard Specifications.
2. ¾” Maximum, Medium gradation for deep lifts within City of San Jose Jurisdiction conforming to requirements of Section 39, Asphalt Concrete, of the City Standard Specifications.
3. ½” Maximum, for 2” overlay and final lift within County jurisdiction conforming to requirements of Section 39, Asphalt Concrete, of the Caltrans Standard Specifications.
4. ¾” Maximum, Medium gradation for deep lifts within County jurisdiction conforming to requirements of Section 39, Asphalt Concrete, of the Caltrans Standard Specifications.

E. Tack Coat shall be Grade SS1h and conform to requirements of Section 94, Asphaltic Emulsions, of the Caltrans Standard Specifications.

F. Reclaimed Asphalt Pavement may be substituted in accordance with Section 39, Asphaltic Concrete, of the Caltrans Standard Specifications.

2.02 RUBBERIZED HOT MIX ASPHALT

A. Rubberized Hot Mix Asphalt shall be designed and installed by the Standard Construction Process.

B. Rubberized Hot Mix Asphalt shall be Type RHMA-G and conform to requirements Section 39, Asphalt Concrete, of the Caltrans Standard Specifications.

C. Asphalt Rubber Binder shall consist of an asphalt binder, an asphalt modifier and a crumb rubber modifier.

1. Asphalt Binder and be PG 64-10 and conform to requirements of Section 92, Asphalt Binders, of the Caltrans Standard Specifications.
2. Asphalt Modifier shall conform to requirements of Section 39, Asphalt Concrete, of the Caltrans Standard Specifications.
3. Crumb Rubber Modifier shall conform to requirements of Section 39, Asphalt Concrete, of the Caltrans Standard Specifications.

D. Aggregate shall conform to the following:

1. ½" Maximum, for 2" overlay and final lift within County jurisdiction conforming to requirements of Section 39, Asphalt Concrete, of the Caltrans Standard Specifications.
2. ¾" Maximum, Medium gradation for deep lifts within County jurisdiction conforming to requirements of Section 39, Asphalt Concrete, of the Caltrans Standard Specifications.

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E. Tack Coat shall be Grade SS1h and conform to requirements ofSection 94, Asphaltic Emulsions, of the Caltrans Standard Specifications.

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 aggregate base before proceeding with the placement of asphalt paving.

3.02 INSTALLATION

A. Prepare subgrade in accordance with Section 31 00 00, Earthwork.

B. If shown, place and prepare aggregate base in accordance with Section 32 11 23, Aggregate Base.

C. If shown, place and prepare geosynthetics in accordance with Section 31 34 19, Geosynthetic Soil Reinforcement

D. Installation of asphalt concrete under the Standard Construction Process and shall conform to the requirements of Section 39, Asphalt Concrete, of the Caltrans Standard Specifications, and the requirements of Section 30, Deep Lift Asphalt Base, and Section 39, Asphalt Concrete, of the City Standard Specifications.

E. Apply tack coat in accordance with Engineer's direction.

F. All conforms, wedge grinds and cold joints shall be sand sealed with a tack coat of SS-1h and sand sealed immediately after paving.

G. Crack filling, where required by the Engineer, shall be performed after cold planing and the removal and replacement of asphalt concrete pavement. Where required, all materials, plants and vegetation shall be removed from cracks prior to replacement of filler.

H. Adjust utilities to grade in accordance with Section 33 05 10, Adjust Frame and Cover to Grade.

3.03 FIELD QUALITY CONTROL

A. Contractor shall perform field tests on material in accordance with Contractor's approved testing plan, or in accordance with Section 39, Asphalt Concrete, of the Caltrans Standard Specifications.

3.04 CORRECTIVE WORK

A. If the finished surface of the asphalt concrete on the traffic lanes does not meet the specified surface tolerances, it shall be brought into tolerance by either (1) removal and replacement, or (2) placing an overlay of asphalt concrete. The Engineer will select the method. The corrective work shall be at the Contractor's expense. Abrasive grinding will not be allowed for corrective action. A drop off of more than 1.75 inches will not be allowed at any time between adjacent lanes open to public traffic.

END OF SECTION 32 12 16

SECTION 32 16 00

CURBS, GUTTERS, SIDEWALKS AND DRIVEWAYS

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for placing curbs, gutters, sidewalks, retaining curbs, valley gutters, driveways, bus pads, maintenance vehicle pullouts and curb ramps of various types.

1.02 RELATED SECTIONS

A. Section 01 78 39, Project Record Documents

B. Section 31 00 00, Earthwork, for subgrade preparation .

C. Section 32 11 23, Aggregate Base Courses

D. Section 32 16 13.30, Concrete

1.03 REFERENCED STANDARDS

A. American Society for Testing and Materials (ASTM):

1. ASTM C78 Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)

B. State of California, Department of Transportation (Caltrans), Standard Specifications 2018:

2. Section 73, Concrete Curbs and Sidewalks
3. Section 90, Concrete

C. County of Santa Clara, Roads & Airports Department, Standard Specifications May 2000, and Standard Specifications Amendments January 7, 2011

D. City of San Jose, Department of Public Works, Standard Specifications July 1992.

1. Section 73, Concrete Curbs and Sidewalks

E. Valley Transportation Authority, Bus Stop and Passenger Facility Standards, March 2010.

1.04 SUBMITTALS

A. General: Refer to Special Conditions for submittal requirements and procedures.

B. Mix Design: Submit proposed mix designs for each concrete mixture 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.

D. 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.

1.05 MEASUREMENT AND PAYMENT

A. Measurement:

1. Concrete Curb, of various types, shall be measured by the cubic yard.
2. Concrete Curb and Gutter, of various types, shall be measured by the cubic yard.
3. Concrete Deepened Curb, of various types, shall be measured by the cubic yard.
4. Concrete Bus Pad shall be measured by the Square Foot.
5. Sidewalk, of various types shall be measured by the Square Foot.
6. Driveway, of various types shall be measured by the Square Foot.
7. Median Paving, of various types, shall be measured by the Square Foot.
8. Curb Ramp and wheelchair ramps, of various types, shall be measured by unit count.
9. Passageway, of various types, shall be measured by the Square Foot.
10. Concrete Valley Gutter, of various types, shall be measured by the Square Foot.
11. Concrete Maintenance Vehicle Pullout, of various types, shall be measured by the Square Foot.

B. Payment:

1. The contract price paid per cubic yard for Concrete Curb shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in placing curbs of various type complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.
2. The contract price paid per cubic yard for Concrete Curb and Gutter shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in placing curbs and gutters of various type complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.
3. The contract price paid per cubic yard for Concrete Deepened Curb of various types shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in placing deepened curbs with and without gutter of various type complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.
4. The contract price paid per Square Foot for Concrete Bus Pad, shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in placing concrete bus pads complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.
5. The contract price paid per Square Foot for Sidewalk, shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in placing sidewalks of various type complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.
6. The contract price paid per Square Foot for Driveway shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in placing driveways of various type complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.
7. The contract price paid per Square Foot for Median Paving, shall include full

compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in placing median paving of various type complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

8. The contract unit price paid per Each for Curb Ramp shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in placing wheelchair ramps and curb ramps of various type complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.
9. The contract unit price paid per Square Foot for Passageway shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in placing passageways of various type complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.
10. The contract price paid per Square Foot for Concrete Valley Gutter shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in placing valley gutters of various type complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.
11. The contract unit price paid per Square Foot for Concrete Maintenance Vehicle Pullout shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in placing concrete MVPs of various type complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 GENERAL

A. Materials for concrete curb, bus pads, gutter, sidewalk, driveway, island paving, and curb ramp shall conform to the provisions of the agency having jurisdiction and these technical specifications. Agencies having jurisdiction shall be defined as follows:

1. VTA Standards for all Concrete Headers and Concrete Bus Pads. Concrete Headers shall conform to the provisions of 32 16 13.30, Concrete Headers.
2. City of San Jose Standards for all facilities on Capitol Avenue, South Capitol Avenue, Kollmar Drive, Swift Avenue, TPSS 34, Eastridge Parking Lot and Eastridge Station.
3. County of Santa Clara Standards for all facilities on Capitol Expressway and TPSS 33.

2.02 CONCRETE

A. Concrete shall conform to the following requirements:

1. VTA: Minor Concrete conforming to Section 90, Concrete, of the Caltrans Standard Specifications with the following additional requirements.
   a. Concrete shall have a flexural strength of 650 psi at 28 days to be determined by ASTM C78.
   b. Fiber reinforcement shall be 0.5” length polypropylene fibers. Apply to concrete at a rate of 1.5 lbs per cubic yard.
2. City of San Jose: Minor Concrete conforming to Section 73, Concrete Curbs and Sidewalks, and Section 90, Concrete, of the Caltrans Standard Specifications.

3. County of Santa Clara: Minor Concrete conforming to Section 73, Concrete Curbs and Sidewalks, and Section 90, Concrete, of the Caltrans Standard Specifications.

2.03 CEMENT

A. Cement shall conform to the following requirements:

1. VTA: Cement conforming to Section 90, Concrete, of the Caltrans Standard Specifications.
2. City of San Jose: Cement conforming to Section 90, Concrete, of the Caltrans Standard Specifications.
3. County of Santa Clara: Cement conforming to Section 90, Concrete, of the Caltrans Standard Specifications.

2.04 AGGREGATE

A. Concrete aggregate shall conform to the following requirements:

1. VTA: Aggregate conforming to Section 90, Concrete, of the Caltrans Standard Specifications.
2. City of San Jose: Aggregate conforming to Section 90, Concrete, of the Caltrans Standard Specifications.
3. County of Santa Clara: Aggregate conforming to Section 90, Concrete, of the Caltrans Standard Specifications.

2.05 AGGREGATE BASE

A. Aggregate base shall conform to the following requirements:

1. VTA: Aggregate Base Class 2 conforming to Section 32 11 23, Aggregate Base Courses.
2. City of San Jose: Aggregate Base Class 3 conforming to Section 32 11 23, Aggregate Base Courses.
3. County of Santa Clara: Aggregate Base Class 3 conforming to Section 32 11 23, Aggregate Base Courses.

2.06 REINFORCEMENT

A. Reinforcement shall conform to the following requirements:

1. VTA: Reinforcement conforming to Section 52, Reinforcement, of the Caltrans Standard Specifications.
2. City of San Jose: Reinforcement conforming to Section 52, Reinforcement, of the Caltrans Standard Specifications.
3. County of Santa Clara: Reinforcement conforming to Section 52, Reinforcement, of the Caltrans Standard Specifications.

2.07 DETECTABLE WARNING SURFACE

A. Detectable Warning Surface shall conform to the following requirements:

1. City of San Jose: Conforming to the City Standard Details.

2. County of Santa Clara: Conforming to Section 73, Concrete Curbs and Sidewalks, of the Caltrans Standard Specifications.

2.08 HIGH STRENGTH CONCRETE

A. Where shown on the Plans or directed by the Engineer, construct driveways and driveway approaches with a high-strength concrete mix design to restore property access. Concrete shall meet the following requirements:

1. Compressive strength of 3000 psi at 24 hours.

B. Coordinate with Engineer for testing criteria and criteria for reopening driveways.

PART 3 – EXECUTION

3.01 EXAMINATION

A. The Contractor shall call for an inspection by the Engineer and obtain written acceptance of the forms and base before proceeding with the placement of concrete.

B. The aggregate base to receive concrete, 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 PREPARATION OF SUBGRADE

A. Excavate for and prepare the sub grade as specified in 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.

3.03 JOINTS

A. Construct construction joints, expansion joints, and tooled joints per plans and the standards of the authority having jurisdiction.

3.04 FINISH

A. Finish concrete per the standards of the authority having jurisdiction.

3.05 CURING AND PROTECTION

A. Apply curing compounds and membranes per the standards of the authority having jurisdiction.

B. Protect concrete from traffic and vandalism.

3.06 FIELD QUALITY CONTROL

A. Contractor shall perform field tests on material in accordance with Contractor's approved testing plan, or in accordance with Section 73, Concrete Curb and Sidewalks, of the Caltrans Standard Specifications.

END OF SECTION 32 16 00

SECTION 32 16 13.30

CONCRETE HEADER

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for placing concrete headers of various types.

1.02 RELATED SECTIONS

A. Record Document procedures are specified in Section 01 78 39, Project Record Documents.

B. Earthwork is specified in Section 31 00 00, Earthwork.

C. Aggregate Base is specified in Section 32 11 23, Aggregate Base Courses.

1.03 REFERENCED STANDARDS

A. State of California, Department of Transportation (Caltrans), Standard Specifications 2018:

1. Section 52, Reinforcement
2. Section 90, Concrete

B. Valley Transportation Authority, Light Rail Transit Standard Detail Manual, 2001.

1.04 SUBMITTALS

A. General: Refer to Special Conditions for submittal requirements and procedures.

B. Mix Design: Submit proposed mix designs for each concrete mixture 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.

D. 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.

1.05 MEASUREMENT AND PAYMENT

A. Measurement: Concrete Header shall be measured by the Linear Foot.

B. Payment: The contract price paid per Linear Foot for Concrete Header shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in placing concrete headers of various types complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 CONCRETE

A. Concrete shall conform to Section 90, Concrete, of the Caltrans Standard Specifications. Concrete shall have a 28 day compressive strength of 4000 psi.

2.02 CEMENT

A. Cement shall be Type II in conformance with to Section 90, Concrete, of the Caltrans Standard Specifications.

2.03 AGGREGATE

A. Aggregate shall be 1 inch max gradation in conformance with Section 90, Concrete, of the Caltrans Standard Specifications.

2.04 AGGREGATE BASE

A. Aggregate Base conforming to Section 32 11 23, Aggregate Base Courses.

2.05 REINFORCEMENT

A. Reinforcement shall be Grade 60 in conformance with Section 52, Reinforcement, of the Caltrans Standard Specifications.

PART 3 – EXECUTION

3.01 EXAMINATION

A. The Contractor shall call for an inspection by the Engineer and obtain written acceptance of the forms and base before proceeding with the placement of concrete.

B. The aggregate base to receive concrete, 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 PREPARATION OF SUBGRADE

A. Excavate for and prepare the sub grade as specified in 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.

3.03 JOINTS

A. Construct construction joints, expansion joints, and tooled joints per VTA Standard Details.

3.04 FINISH

A. Finish concrete per VTA Standard Details.

3.05 CURING AND PROTECTION

A. Apply curing compounds and membranes per VTA Standard Details.

B. Protect concrete from traffic and vandalism.

3.06 FIELD QUALITY CONTROL

A. Contractor shall perform field tests on material in accordance with Contractor's approved testing plan, or in accordance with Section 90, Concrete, of the Caltrans Standard Specifications.

END OF SECTION 32 16 13.30

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SECTION 32 17 24

TRAFFIC STRIPES, PAVEMENT MARKINGS, AND PAVEMENT MARKERS

PART 1 GENERAL

1.01 SCOPE

A. This Section includes requirements for applying and removing traffic stripes and pavement markers.

1.02 REFERENCE STANDARDS

A. State of California, Department of Transportation (Caltrans) Standard Specifications:

1. Section 81 Miscellaneous Traffic Control Devices
2. Section 82 Signs and Markers
3. Section 84 Markings

1.03 SUBMITTALS

A. Submittals shall conform to Section 84-2.01C, Submittals, of the Standard Specifications, and shall be on the Caltrans Authorized Material List for signing and delineation materials.

1.04 MEASUREMENT AND PAYMENT

A. Measurement:

1. THERMOPLASTIC TRAFFIC STRIPE shall be measured by the Linear Foot.
2. THERMOPLASTIC PAVEMENT MARKING shall be measured by the Square Foot.
3. OBJECT MARKER shall be measure by the unit count.

B. Payment:

1. The contract unit prices paid per Linear Foot for THERMOPLASTIC TRAFFIC STRIPE shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing THERMOPLASTIC TRAFFIC STRIPES (regardless of the number, widths and patterns of individual stripes involved in each dashed traffic stripe, and solid traffic stripes) complete in place, including installation of the pavement markers that make up the traffic stripes, establishing alignment for stripes and including layout work, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefore.

2. The contract unit prices paid per Square Foot for THERMOPLASTIC PAVEMENT MARKING

shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing THERMOPLASTIC PAVEMENT MARKING, complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefore.

3. The contract price paid per unit for OBJECT MARKER shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing OBJECT MARKER, including furnishing and installing post, and panels, complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefore.

PART 2 PRODUCTS

2.01 THERMOPLASTIC TRAFFIC STRIPES AND PAVEMENT MARKINGS

A. Thermoplastic traffic stripes and pavement markings shall conform to the provisions in Sections 84, "Markings," of the Standard Specifications, details shown on the drawings, and these Technical Specifications.

1. Paint for traffic stripes and pavement markings in the City of San Jose shall also conform to the City of San Jose Standard Specifications, Section 84-1, “General,” and 84-2, “Thermoplastic Traffic Stripes and Pavement Markings.”

2.02 PAVEMENT MARKERS

A. Pavement markers shall conform to the provisions in Section 81-3, "Pavement Markers," of the Standard Specifications, details shown on the drawings, and these technical specifications. Pavement markers in the City of San Jose shall conform to the City of San Jose Standard Specifications.

PART 3 EXECUTION

3.01 INSTALLATION

A. The Contractor shall contact the City of San Jose Department of Streets and Parks, South Maintenance Yard, 4420 Monterey Road, San Jose, (408) 227-4691 to obtain templates for pavement markings within the City of San Jose.

B. Install thermoplastic traffic stripes and pavement markings in accordance with the provisions in Sections 84-2.03, "Construction," of the Standard Specifications, details shown on the drawings, the Standard Plans, and these Technical Specifications.

C. Install pavement markers in accordance with the provisions in Section 81-3.03, "Construction," of the Standard Specifications, details shown on the drawings, the Standard Plans, and these Technical Specifications.

END OF SECTION 32 17 24

SECTION 32 17 26

TACTILE WARNING SURFACING

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for furnishing and installing Tactile Warning Band, Decision Tiles, and Detectable Directional Bar tile as indicated in Drawings.

1.02 RELATED SECTIONS

A. Section 03 30 00 – Cast-in-Place Concrete

B. Section 03 62 00 – Non Shrink Grouting

C. Section 07 16 00 – Cementitious and Reactive Waterproofing

1.03 REFERENCED 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 Method for Absorption and Bulk Specific gravity of Dimension Stone
4. ASTM C418 Standard Test Method for Abrasion Resistance for 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 the Taber 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 Landing)
9. ASTM C1026 Standard Test Method for Measuring the Resistance of Ceramic and Glass tile to 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 Practices 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 Plastics

15.	ASTM D696	Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics Between -30 degrees C and 30 degrees C with a Vitreous Silica Dilatometer
16.	ASTM D790	Standard Test Method for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
17.	ASTM D1037	Standard Test Method for Evaluating Properties of Wood-Base Fiber and Particle Panel Materials
18.	ASTM D2486	Standard Test Method 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 Test Method for Exposing Nonmetallic Materials in Accelerated Test Devices that Use Laboratory Light Sources
22.	ASTM G155	Standard Test Method 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.

1.04 SUBMITTALS

A. General

1. Submittals for Tactile Warning Surfacing must be made in accordance with the provisions in these technical specifications.
2. Product Data: Submit manufacturer's product data and installation instructions for the specified tactile warning and directional tiles including adhesives, sealants, and fasteners.
   a. Include type and models of tiles to be installed and method of installation for each model.
   b. Include dimensioned drawings of tile surface profiles.
   c. Include maintenance and cleaning instructions for the tiles.
3. 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.
   c. Fabrication details.
   d. Fastener types and locations.
   e. Internal flange and grouting details, where applicable.
4. Samples: Submit full-size samples of the types of tactile warning and directional tiles to be installed in each color specified for the Architect's approval. Samples must match the Architect's control samples.
5. 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.
6. Installer's Qualifications: Submit evidence of the tile manufacturer's approval of the qualifications and experience of the proposed installer.

1.05 MEASUREMENT AND PAYMENT

A. Measurement: Tactile Warning Surfacing must be measured by the square foot.

B. Payment: The contract price paid per square foot for Tactile Warning Surfacing must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Tactile Warning Surfacing complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

C. Furnishing of extra stock is included in the contract price paid for tiles installed.

1.06 EXTRA STOCK

A. Furnish not less than (five percent) additional tiles of the total amount installed at the project site. Deliver extra stock to warehouse (within 30 mile radius of the project site) designated by VTA. Furnish extra stock materials from same manufactured lot as materials installed and enclose in protective packaging with appropriate identification.

1.07 QUALITY CONTROL

A. Provide surface applied, Truncated Dome Tactile Warning Tiles and accessories as produced by a single manufacturer.

1. The manufacturer must have a minimum of three (3) years experience in the manufacture of plastic composite tactile systems which are certified by the U. S. Department of Transportation as meeting the Americans with Disabilities Act Accessibility Guidelines.
2. Manufacturer must be able to demonstrate similar installations at other transit properties that have been performing successfully for periods not less than two years.

B. Installer's Qualifications: Engage an experienced Installer certified in writing by tactile manufacturer as qualified for installation, who has successfully completed tile installations similar in material, design, and extent to that indicated for the Project.

1. Installers must not begin work until they have been trained by Manufacturer.
2. Manufacturer's supervisor must be present at all times during the installation of the Detectable/Tactile Warning Surfaces.

C. Detectable/Tactile Warning Surface Manufacturer must be required to inspect and approve installation of work and to provide certifications of inspection approvals.

D. 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.

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 must be guaranteed in writing for a period of five years from date of Acceptance. The guarantee must include defective work, breakage, deformation, fading and chalking of finishes, and loosening of tiles, and must cover the cost of labor and materials for repair or replacement.

PART 2 – PRODUCTS

2.01 MANUFACTURER

A. Basis of Design: Armor-Tile, 300 International Drive Suite 100, Williamsville, NY, 14221. Phone: (800) 682-2525. Website: www.armor-tile.com.

1. Proprietary Products: Use of manufacturer's proprietary product names to designate materials and finishes is not intended to imply that products named are required to be used to the exclusion of equivalent products of other manufacturers. Equivalent products must meet or exceed the requirements of these specifications. Furnish manufacturer's material data that indicates compliance with the requirements of Part 1 of this Section.

2.02 MATERIALS

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 percent.
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 percent.
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}/degrees 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 percent.
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 percent.

D. In addition to compliance with the specified test criteria and characteristics, detectable tactile warning surfacing products must have been successfully field tested in service for a minimum of two years.

E. Detectable Warning Surfaces must 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.

2.03 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 4: Directional Way-Finding Bar Tile.

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 must be uniform and homogeneous throughout the tile and in conformance with FED-STD-595C as follows:

1. Yellow: Federal Color No. 33538.

2.04 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 316 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.

2.05 ACCESSORIES

A. Adhesives: As recommended by the tile manufacturer.

B. Perimeter sealant: As recommended by the tile manufacturer.

1. Color: Translucent

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 must 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.

END OF SECTION 32 17 26

SECTION 32 31 13

CHAIN LINK FENCES, RAILINGS AND GATES

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for placing chain link fences and gates of various types.

1.02 RELATED SECTIONS

A. Section 01 78 39, Project Record Documents.

B. Section 32 31 10, Ornamental Fence and Gate.

C. Section 32 31 26, Wire Fences and Gates.

1.03 REFERENCED STANDARDS

A. State of California, Department of Transportation (Caltrans), Standard Specifications 2018:

1. Section 56, Overhead Sign Structures, Standards, And Poles
2. Section 80, Fences

1.04 SUBMITTALS

A. General: Refer to Special Conditions for submittal requirements and procedures.

B. Product Data: Submit product data for the following:

1. Concrete Mix Design
2. Fence Posts
3. Fence Material
4. Railing Material
5. Gates and Hardware

C. 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.

1.05 MEASUREMENT AND PAYMENT

A. Measurement:

1. Chain Link Fence, of various types, shall be measured by the Linear Foot.
2. Pedestrian Railing shall be measured by the Linear Foot.
3. 3’ Gate shall be measured by the unit count.
4. 20’ Gate shall be measured by the unit count.
5. 25’ Gate shall be measured by the unit count.
6. 30’ Gate shall be measured by the unit count.

B. Payment:

1. The contract price paid per linear foot for Chain Link Fence, of various types, shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in placing chain link fence in place of various types, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.
2. The contract price paid per linear foot for Pedestrian Railing shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in placing Pedestrian Railing in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.
3. The contract price paid per unit count for 3’ Gate shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in gates complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.
4. The contract price paid per unit count for 20’ Gate shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in gates complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.
5. The contract price paid per unit count for 25’ Gate shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in gates complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.
6. The contract price paid per unit count for 30’ Gate shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in gates complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 FENCE AND GATE MATERIAL

A. Fence and gate material shall conform to Section 80, Fences, of the Caltrans Standard Specifications.

2.02 RAILING MATERIAL

A. Pedestrian Railing material shall conform to Section 56, Overhead Sign Structures, Standards, And Poles of the Caltrans Standard Specifications.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install fences and gates in accordance with Section 80, Fences, of the Caltrans Standard Specifications.

B. Install pedestrian railing in accordance with Section 56, Overhead Sign Structures, Standards, And Poles of the Caltrans Standard Specifications.

END OF SECTION 32 31 13

SECTION 32 31 19

DECORATIVE METAL FENCES

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes the requirements for furnishing and installing Picket Fences and Decorative Picket Fences.

1.02 RELATED SECTIONS

A. Section 03 62 00 – Non-Shrink Grouting

B. Section 05 50 00 - Metal Fabrications

C. Section 05 05 60 – Metal Welding

D. Section 09 91 00 – Painting

1.03 REFERENCED STANDARDS

A. ASTM International (ASTM):

1. ASTM A36 Standard Specification for Carbon Structural Steel
2. ASTM A53 Schedule 80. Standard Specification for Pipe
3. ASTM A123 Standard Specification for Zing (Hot-Galvanized) Coatings on Iron and Steel Products
4. ASTM A153 Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
5. ASTM A385 Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip)
6. ASTM A501 Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing

B. American Welding Society (AWS):

1. D1.1 Structural Welding Code – Steel

C. Steel Structures Painting Council (SSPC):

1. SP3 Power Tool Cleaning

1.04 SUBMITTALS

A. General

1. Submittals for Picket Fences and Decorative Picket Fences must be made in accordance with the provisions in these technical specifications.
2. The Contractor must submit the following:
   a. Shop Drawings: Shop Drawings: Submit shop drawings of all Picket Fences

and Decorative Picket Fence fabrications to Owners Representative for approval, showing sizes and thicknesses of all members, types of materials, methods of connection and assembly, complete dimensions, clearances, anchorage, relationship to surrounding work by other trades, shop paint and protective coatings, and other pertinent details of fabrication and installation.

1) Indicate profiles, sizes, connection attachments, reinforcing, anchorage, openings, size and type of fasteners, and any accessories.
2) Include erection drawings, elevations, applicable details, and field dimensions.
3) Indicate welded connections using standard AWS welding symbols. Indicate net weld lengths.

b. Samples: Submit duplicate samples of all materials to be furnished under this Section in size and form requested by Engineer.

c. Do not order materials or begin fabrication until Engineer's approval of submittals has been obtained.

d. Furnish to the Contractor with copy to the Engineer, a certified statement that the shop- applied galvanizing and finishes conform to these Specifications including compliance with application thickness and adhesion.

3. All submittals must be made to VTA for review. The Contractor must not order materials, begin fabrication, or begin construction of work related to the submittal, until the submittal has been reviewed and stamped by VTA with a shop drawing stamp marked “No Exception Taken” or "Make Corrections Noted" and returned to the Contractor by VTA.

1.05 MEASUREMENT AND PAYMENT

A. Measurement: Decorative Picket Fences must be measured by the linear foot.

B. Payment: The contract price paid per linear foot for Decorative Picket Fences must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Decorative Picket Fences complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

1.06 PRODUCT HANDLING AND STORAGE

A. Materials must be carefully handled and stored under cover in manner to prevent deformation and damage to the materials and to shop finishes, and to prevent rusting and the accumulation of foreign matter on the metal work. All such work must be repaired and cleaned before erection.

PART 2 – PRODUCTS

2.01 MATERIALS

A. General: Materials must be new stock, free from defects impairing strength, durability or appearance and of best commercial quality for each intended purpose.

1. Solid steel members, hardware, and fasteners must be fabricated of structural steel conforming to ASTM A36. Steel must be hot-dip galvanized steel bar.
2. Steel pipe must be seamless galvanized steel pipe conforming to ASTM A53, Schedule 80.
3. Steel tubing must be structural galvanized steel square tubing conforming to ASTM A501.

B. Connections must be continuous welded type for rigid construction, with welds ground smooth. Welding must conform to applicable requirements of AWS D1.1.

C. Welded rods must conform to AWS Standards and the recommendations of the welding rod manufacturer. Welding of steel must conform to AWS D1.1.

D. Provide all anchors, bolts, sockets, sleeves, and other parts required for securing each item of work of this Section of the construction. Furnish required inserts and sleeves for installation in concrete under Section 03 30 00 – Cast-in-Place Concrete.

E. Exposed fastenings must be of the same material and finish as the metal to which applied, unless otherwise noted.

2.02 FINISH

A. Painted:

1. Color: Sherwin Williams SW7103 - Whitetail

PART 3 – EXECUTION

3.01 FABRICATION AND WORKMANSHIP

A. Metal surfaces must be clean and free from mill scale, flake, rust and rust pitting; well formed and finished to shape and size, true to details with straight, sharp lines and angles and smooth surfaces. Curved work must be to true radii. Exposed sheared edges must be eased.

B. Weld all permanent connections. Weld must be continuous on all exposed surfaces and where required for strength on concealed surfaces. Exposed welds must be ground flush and smooth, with voids filled with metallic filling compound. Tack-welding will not be permitted. Do not use screws or bolts where they can be avoided. Where used, heads must be countersunk, screwed up tight and threads nicked to prevent loosening.

C. Fastenings must be concealed where practicable. Thickness of metal and details of assembly and supports must give ample strength and stiffness. Joints exposed to weather must be formed to exclude water.

D. Do all cutting, punching, drilling, and tapping required for attachment of hardware and of work of other Sections where so indicated or where directions for same are given prior to, or with approval of, shop drawings.

E. Live loads must be not less than the minimum required by Code. Where specific live loads are not set forth and are not given on the Drawings or in this specification, designs must be such as to support the live loads as required by the California Building Code, without failure, without deflection of more than L/360 of length of any number, and without permanent deformation, all with a safety factor of not less than 2-1/2 to 1.

3.02 SHOP COATINGS

A. Immediately before galvanizing, fence, gate, railing and edging materials must have all rust, loose mill scale, dirt, weld flux, weld spatter, and other foreign material removed with wire brushes and/or steel scrapers. Power tool clean in accordance with SSPC SP 3. Remove grease and oil by use of recommended solvent.

B. Galvanizing: Components must be hot-dip galvanized, including all bolts, nuts, washers, and other related ferrous metal items used therewith.

1. Hot-dip galvanizing process must comply with ASTM A123, ASTM A153, ASTM A385, and ASTM A386 as applicable. After galvanizing, processed items must be straightened to remove all warpage and distortion caused by the process.
2. Furnish certified statement that galvanizing complies fully with this Specification.

C. Shop Painting: Metal under this Section must be given a shop coat of rust inhibitive primer of type specified herein-before. Metals to be shop and field painted must meet the requirements specified under Section 05 50 00 – Metal Fabrications, and under Section 09 91 00 – Painting.

1. Immediately before shop painting, remove grease and oil by use of solvent recommended by paint manufacturer. Produce smooth, even finishes.
2. Apply paint by spray process in strict accordance with manufacturer's printed instructions to uniform thickness(es) recommended by manufacturer. Apply thoroughly and evenly and work well into corners and joints taking care to avoid sags and runs.
3. Do not paint surfaces to be embedded in granite curb, or to be welded in the field. After field welds are complete, grind smooth and flush, thoroughly clean and then apply specified primer over all unprimed surfaces in the field by brush or roller.
4. After erection, sand smooth and retouch all portions of the shop coats chipped or damaged during erection, and coat all field welds and connections with primer equivalent to that used for the shop coat.

D. Electrolytic Isolation: Isolate dissimilar metals from each other with heavy coating of bituminous paint on contact surfaces in addition to shop coat specified above. Do not permit the bituminous paint in any way to remain on surfaces which are to be exposed or are to receive sealant.

3.03 FINISH SYSTEM

A. Coating system must be factory-applied in conformance with manufacturer's published specifications by airless spray method, within specified range of environmental conditions.

B. Finished coating system must be force-dried at 150 degrees Fahrenheit (65.6 degrees Celsius).

C. Touch up damage in field with zinc rich paint and suitable priming and finishing material, as recommended and supplied by the fabricator to match shop-applied finish.

3.04 INSTALLATION

A. Materials must be carefully handled and stored under cover in manner to prevent deformation and damage to the materials and to shop finishes, and to prevent rusting and the accumulation of foreign matter on the metal work. All such work must be repaired and cleaned prior to erection.

B. Work must be erected square, plumb and true, accurately fitted, and with tight joints and intersections. All anchors, inserts and other members must be embedded or surface mounted per drawings. Later cutting or drilling must be avoided wherever possible.

C. Ornamental metal fence, gate, railing, and edging must be rigidly braced and secured to surrounding construction, and must be tight and free of rattle, vibration, or noticeable deflection after installation.

D. Electrolytic Isolation: Where dissimilar metals are to come into contact with one another, isolate by application of a heavy coating of bituminous paint on contact surfaces in addition to shop coat specified above. Do not permit the bituminous paint in any way to remain on surfaces to be exposed or to receive sealant.

E. Fence, gate, railings, and edging must be of smooth surfaces, plumb and square. Exceptional care must be taken in welding and grinding, filling and surface sanding to provide truly smooth, clean, neat and flush construction throughout, free of all surface defects and defacements.

3.05 TOUCH-UP AND REPAIR WORK

A. Remove and replace work of this section which is improperly located or is not true to line, grade and plumb within tolerances as indicated.

B. Repair damaged components and finishes as recommended by the manufacturer and as indicated herein.

END OF SECTION 32 31 19

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SECTION 32 31 26

WIRE FENCES AND GATES

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes the requirements for furnishing and installing Ornamental Fences and Gates and Ornamental Security Fences and Gates.

1.02 RELATED SECTIONS

A. Section 03 30 00 – Cast-in-Place Concrete

B. Section 03 62 00 – Non-Shrink Grouting

C. Section 05 50 00 - Metal Fabrications

D. Section 05 52 00 – Metal Railings (Stations)

E. Section 08 70 00 – Door Hardware

F. Section 09 91 00 – Painting

G. Division 26 – Electrical

H. Division 27 – Communications

1.03 REFERENCED STANDARDS

A. ASTM International (ASTM):

1. ASTM A36 Standard Specification for Carbon Structural Steel
2. ASTM A53 Schedule 80. Standard Specification for Pipe
3. ASTM A123 Standard Specification for Zing (Hot-Galvanized) Coatings on Iron and Steel Products
4. ASTM A153 Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
5. ASTM A385 Standard Practice for Providing High-Quality Zinc Coaatings (Hot-Dip)
6. ASTM A501 Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing

B. American Welding Society (AWS):

1. D1.1 Structural Welding Code – Steel

C. Steel Structures Painting Council (SSPC):

1. SP3 Power Tool Cleaning

1.04 SUBMITTALS

A. General

1. Submittals for Ornamental Metal Fence and Gate must be made in accordance with the provisions in these technical specifications.
2. The Contractor must submit the following:
   a. Product Data: Material descriptions, construction details, dimension of individual components and profiles, and finishes for the following:
      1) Fence and gate posts, rails, and fittings.
      2) Gates and hardware.
      3) Gate operators, including operating instructions.
      4) Motors: Show nameplate data, ratings, characteristics, and mounting arrangements.
   b. Shop Drawings: Show locations of fence, each gate, posts, rails, and details of gate swing, or other operation, hardware, and accessories. Indicate materials, dimensions, sizes, weights, and finishes of components. Include plans, elevations, sections, gate swing and other required installation and operational clearances, and details of post anchorage, attachment and bracing. Installation procedures and instructions by manufacturer describing all details for a typical fence and gates.
      1) Gate Operator: Show locations and details for installing operator components, switches, and controls. Indicate motor size, electrical characteristics, drive arrangement, mounting, and grounding provisions.
      2) Wiring Diagrams: Power and control wiring [and communication features] [and access control features]. Differentiate between manufacturer-installed and field-installed wiring and between components provided by gate operator manufacturer and those provided by others.
   c. Samples for Initial Selection: Manufacturer's color charts shown on its internet site.
   d. Samples for Verification: Request a color chip from the manufacturer.
   e. Qualification Data: For firms and persons specified in "Quality Assurance" article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.
   f. Maintenance Data: Request the maintenance manual for the gate operator.
3. All submittals must be made to VTA for review. The Contractor must not order materials, begin fabrication, or begin construction of work related to the submittal, until the submittal has been reviewed and stamped by VTA with a shop drawing stamp marked “No Exception Taken” or "Make Corrections Noted" and returned to the Contractor by VTA.

1.05 MEASUREMENT AND PAYMENT

A. Measurement: Ornamental Security Gates must be measured by each gate.

B. Payment: The contract price paid per gate for Ornamental Security Gates must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Ornamental Security Gates complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

C. Measurement: Ornamental Fencing must be measured by the linear foot.

D. Payment: The contract price paid per linear foot for Ornamental Fencing must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Ornamental Fencing complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

1.06 PRODUCT HANDLING AND STORAGE

A. Materials must be carefully handled and stored under cover in manner to prevent deformation and damage to the materials and to shop finishes, and to prevent rusting and the accumulation of foreign matter on the metal work. All such work must be repaired and cleaned before erection.

1.07 PROJECT CONDITIONS

A. Field Measurements: verify layout information for fences and gates shown on drawings in relation to property survey and existing structures. Verify dimensions by field measurements.

1.08 QUALITY ASSURANCE

A. Installer Qualifications: an experienced installer who has completed fences and gates similar in material, design, and extent to those indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.

B. Source Limitations for Fences and Gates: obtain each color, grade, finish, type, and variety of components for fences and gates from one source with resources to provide fences and gates of consistent quality in appearance and physical properties.

C. Electrical Components, Devices, and Accessories: listed and labelled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. UL Standard: Provide gate operators that comply with UL 325.

E. Emergency Access Requirements: comply with requirements of authorities having jurisdiction for automatic gate operators serving as a required means of access.

PART 2 – PRODUCTS

2.01 MANUFACTURER

A. Ornamental Security Fences and Gates: Basis of Design: Omega Max Fence and Gate as manufactured by Omega II Fence Systems, or VTA approved equal.

1. Proprietary Products: Use of manufacturer's proprietary product names to designate materials and finishes is not intended to imply that products named are required to be used to the exclusion of equivalent products of other manufacturers. Equivalent products must meet or exceed the requirements of these specifications. Furnish manufacturer's material data that indicates compliance with the requirements of Part 1 of this Section.
2. Manufacturer:
   a. OMEGA II FENCE SYSTEMS, A division of Metaltech – Omega inc., 1735, St-Elzear west, Laval (Quebec), Canada, H7L3N6. Phone: (800)-836-6342 and (450)-686-9600. Website: www.omegafence.com.

B. Ornamental Fences and Gates: Basis of Design: Omega Architectural Fence as manufactured by Omega II Fence System or VTA approved equal.

1. Proprietary Products: Use of manufacturer's proprietary product names to designate materials and finishes is not intended to imply that products named are required to be used to the exclusion of equivalent products of other manufacturers. Equivalent products must meet or exceed the requirements of these specifications. Furnish manufacturer's material data that indicates compliance with the requirements of Part 1 of this Section.
2. Manufacturer:
   a. OMEGA II FENCE SYSTEMS, A division of Metaltech – Omega inc., 1735, St-Elzear west, Laval (Quebec), Canada, H7L3N6. Phone: (800)-836-6342 and (450)-686-9600. Website: www.omegafence.com.

C. Gates at TPSS, see Section 05 50 00 – Metal Fabrications.

2.02 MATERIALS

A. Ornamental Security Fence: OMEGA Max Fence:

1. Height: 8-feet unless otherwise indicated in Contract Drawings.
2. The OMEGA MAX panel is made of 8GA, 0.160 in. ± 0.002 in. (4.06mm ± 0.05 mm) Ø steel horizontal bars welded to 8GA, 0.160 in. ± 0.002 in. (4.06mm ± 0.05 mm) Ø steel vertical bars. The 8GA cold-rolled steel rod shall be annealed in conformity with AISI 1018 and ASTM A853-04 (2010). Horizontal bars are welded to vertical bars in accordance with ASTM A1064-15 and ASTM A853-04 (2010). Steel bar c/c spacing is 0.50 in. (12.70 mm) for horizontal bars and 3 in. (76.20 mm) for vertical bars. Bars are electric-resistance welded. These welded bars create clear 0.34 in. x 2.84 in. (8.64 mm x 72.14 mm) rectangles. The cold-rolled steel bars tensile strength is 75000 psi (515 MPa) and breaking load is 1499 lb (680.0.4 kg) per bar. Longitudinal camber and transverse camber shall not exceed 0.094 in. (2.5 mm). Panel diagonal measurements shall not present more than a 0.125 in. (3.2 mm) difference. Furthermore, the horizontal and vertical bar right angle shall not vary by more than 1 degree. Cut bars shall not exceed top, bottom nor panel sides.

A. Ornamental Security Gate: OMEGA Max Gate:

1. Panel: OMEGA MAX panels are welded to gate frames.
2. The gate frame is made in conformity with ASTM F900-11 from 16GA cold-formed galvanized steel square tubes of 1 ½ in. x 1 ½ in. (38 mm X 38 mm) for horizontal frame components and 2 in. x 2 in. (50 mm x 50 mm) for vertical frame components to form a rigid frame. For gates wider than 99.16 in. (2519 mm), a 1 ½ in. x 1 ½ in. (38 mm X 38 mm) vertical square support shall be added to the frame to increase solidity. For gates higher than 96.16 in. (2442 mm), a 1 ½ in. x 1 ½ in. (38 mm X 38 mm) horizontal support shall be added to insure frame physical integrity.

B. Ornamental Fence: OMEGA Architectural Fence:

1. Height: 6-feet unless otherwise indicated in Contract Drawings.
2. Steel Mesh Fence Panels: The wire mesh fence panels , is welded by resistance using 6 gauge - 0.192" (4.88 mm) (pre-galvanized steel wire, welded at each crossing to form rectangles of 2 in. x 6 in. (50 mm x 150 mm). The cold rolled wire shall have a tensile strength of at least 75,000 psi (515 Mpa) and a 2 172 lbs (985 Kg) break strength as per ASTM A185 & A853. One end of the vertical wires of the panel shall exceed 1-inch (25 mm) from the last or the first horizontal wire thereby creating a spiked top when installed. The bottom end must be

flush. Panels shall have two vertical folds per each 6-foot wide panel and must follow the pattern as indicated in Contract Drawings. Panel camber may not exceed 0.094'' (2.5 mm).

2.03 ACCESSORIES

A. Painted steel posts, flat bar, anchors, and aluminum post caps as stated in the Contract Drawings and must conform to Section 05 50 00 – Metal Fabrications.

B. All exposed fasteners and members must be painted to match. Where dissimilar metals are used, neoprene washers must be used to prevent galvanic action.

2.04 COATINGS

A. Zinc Coating:

1. The horizontal and vertical bars are coated with a minimum of 0.50 oz/sq.ft. (150 g/m^2) zinc (galvanizing process before welding) in conformity with ASTM A641-09a(2014) Class 1.
2. The square fence and gate posts are coated with a minimum of 0.90 oz/sq.ft. (275 g/m^2) zinc (pre-galvanizing) in conformity with ASTM A653-15 G90..
3. The flat vertical bars are coated with a minimum of 1.5 oz/sq.ft. (530 g/m^2) zinc (hot-dip galvanizing) in conformity with ASTM A123-13 G75.

B. Color: As stated in the Contract Documents.

2.05 HINGES

A. Structurally designed to support all gates without deformation during opening and closing.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for [a verified survey of property lines and legal boundaries,] site clearing, earthwork, pavement work, and other conditions affecting performance.

B. Do not begin installation before final grading is completed, unless otherwise permitted by the Engineer.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of 500 ft. (152.5 m) or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

3.03 INSTALLATION GENERAL

A. Install fencing on established boundary lines as indicated in the Contract Drawings.

B. Post Excavation: Drill or hand-excavate holes for posts to diameters and spacing indicated, in firm, undisturbed or compacted soil.

C. Post Setting: Set posts in concrete footing. Protect portion of posts above ground from concrete splatter. Place concrete around posts and consolidation. Using mechanical devices to set posts is not permitted. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during placement and finishing operations until concrete is sufficiently cured.

1. Dimensions and Profile: As indicated in ContractDrawings.
2. Space line posts uniformly at centre to centre.

3.04 GROUT AND ANCHORING CEMENT

A. Nonshrink, Nonmetallic Grout: Premixed, factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107. Provide grout, recommended in writing by manufacturer, for exterior applications.

B. Erosion-Resistant Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with potable water at Project site to create pourable anchoring, patching, and grouting compound. Provide formulation that is resistant to erosion from water exposure without needing protection by a sealer or waterproof coating and that is recommended in writing by manufacturer for exterior applications.

3.05 GROUNDING AND BONDING

A. TBD.

3.06 FIELD QUALITY CONTROL – GROUNDING

A. TBD.

3.07 MAINTENANCE

A. Inspection:
1. A through visual inspection shall be done annually.
2. This inspection must include overall verification of physical condition. Moveable parts shall be adjusted, if needed, every 5 years.

3.08 GATE ADJUSTING

A. Gate: Adjust gate to operate smoothly, easily, and quietly, free from binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.

B. Automatic Gate Operator: Energize circuits to electrical equipment and devices. Adjust operators, controls, safety devices, alarms, and limit switches.
1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Test controls, alarms, and safeties. Remove damaged and malfunctioning units, replace with new units, and retest.

C. Lubricate hardware and other moving parts .

3.09 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's personnel to adjust, operate, and maintain gates.

1. Test and adjust operators, controls, alarms, safety devices, hardware, and other operable components. Replace damaged or malfunctioning operable components .
2. Train Owner's personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules .
3. Schedule training with Owner at least seven days' advance notice .

END OF SECTION 32 31 26

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SECTION 32 33 00

SITE FURNISHINGS

PART 1 – GENERAL

1.01 SUMMARY

A. This section includes specifications for:

1. Benches
2. Trash Receptacles

1.02 RELATED SECTIONS

A. Section 03 30 00 – Cast-in-Place Concrete

B. Section 05 50 00 – Metal Fabrications

1.03 REFERENCED STANDARDS

A. ASTM International (ASTM):

1.	ASTM A 536	Standard Specification for Ductile Iron Castings.
2.	ASTM B 117	Standard Practice for Operating Salt Spray (Fog) Apparatus.
3.	ASTM D 522	Standard Test Methods for Mandrel Bend Test of Attached Organic Coatings.
4.	ASTM D 523	Standard Test Method for Specular Gloss.
5.	ASTM D 2247	Standard Practice for Testing Water Resistance of Coatings in 100 percent Relative Humidity.
6.	ASTM D 2794	Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact).
7.	ASTM D 3359	Standard Test Methods for Measuring Adhesion by Tape Test.
8.	ASTM D 3363	Standard Test Method for Film Hardness by Pencil Test.
9.	ASTM G 155	Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials.

B. ISO Testing Standards (ISO):

1.	ISO 1520	Paints and Varnishes – Cupping Test.
2.	ISO 2815	Paints and Varnishes – Buchholz Indentation Test

1.04 SUBMITTALS

A. General

1. Submittals for Site Furnishings must be made in accordance with the provisions in these technical specifications.
2. Contractor must submit the following shop drawings, working drawings, color samples, and product data:

a. Product Data: Submit manufacturer's product data, storage and handling requirements and recommendations, installation methods and available colors, styles, patterns and textures.
b. Shop Drawings: Submit manufacturer's shop drawings, including plans and elevations, indicating overall dimensions .
c. Installation and maintenance instructions.
d. Warranty: Manufacturer's standard warranty.
e. Color samples: Submit three manufacturers samples, minimum 2-inch by 2-inch, of materials, finishes, and colors.

1.05 MEASUREMENT AND PAYMENT

A. Measurement: Site Furnishings must be measured by the each item.

B. Payment: The contract price paid per each item for Site Furnishings must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Site Furnishings complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

1.06 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Manufacturer regularly engaged in manufacture of site furnishings with a minimum experience of ten years.

B. Provide reference list of at least ten major transportation authorities, municipalities, universities, or other high-use public environments currently using site seating fabricated by the manufacturer.

1.07 DELIVERY STORAGE AND HANDLING

A. Delivery: Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly identifying product name and manufacturer.

B. Storage: Store materials in clean, dry area in accordance with manufacturer's instructions. Keep materials in manufacturer's original, unopened containers and packaging until installation.

C. Handling: Protect materials and finish during handling and installation to prevent damage.

1.08 WARRANTY

A. Products will be free from defects in material and/or workmanship for a period of one to three years from the date of invoice.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Basis of Design: Benches must be Balance Bench Model SBBAL-72BSS backed bench with cast aluminum frame and formed stainless steel seat as manufactured by Forms+Surfaces or VTA approved equal.

1. Proprietary Products: Use of manufacturer's proprietary product names to designate materials and finishes is not intended to imply that products named are required to be used

to the exclusion of equivalent products of other manufacturers. Equivalent products must meet or exceed the requirements of these specifications. Furnish manufacturer's material data that indicates compliance with the requirements of Part 1 of this Section.

2. Manufacturer: Forms+Surfaces 5055 6th Street, Carpinteria, CA 93013. Phone: (800) 451-0410. Website: www.forms-surfaces.com.

B. Standard Expanded Steel Basket Waste Containers with Steel Dome Top.

2.02 BENCHES

A. Backed benches with cast aluminum frame and formed stainless steel seat.

1. Backed bench: 75-inches long x 23-inches deep x 32.9-inches high. Seat height 17.3-inches, seat depth 18-inches, armrest height 24.7-inches, and seat dividers.
2. Mounting: Surface mount. Provide anchors and stainless steel mounting screws

B. Materials:

1. Bench frames: cast aluminum cantilever type with integral armrests.
2. Seats: formed stainless steel, 2mm (nom. 14 gauge) thickness with 1-inch hexagonal perforations.
3. Seat dividers, color to match bench
4. Fasteners: stainless steel

C. Finishes:

1. Bench frames: polyester powdercoat
   a. Standard Texture from Forms+Surfaces Powdercoat Chart – Color: Aluminum Texture.
2. Seats:
   a. Uncoated stainless steel
      1) Sandstone.
3. Seat dividers:
   a. Powdercoated to match frame.
      1) Sandstone.

2.03 TRASH RECEPTACLES

A. Standard Expanded Steel Basket Waste Containers with Steel Dome Top.

1. Diameter: TBD
2. Height: TBD
3. Capacity: TBD
4. Surface mounted
5. Steel Dome Top Color: Black
6. Basket Color: Black

B. Fasteners:

1. Anchor Bolts: Corrosion resistant and applicable to substrate as recommended by the manufacturer.

C. Fabrication:

1. Shop Assembled litter receptacles.

D. Finishes:

1. Primer: Rust inhibitor.
2. Topcoat: Thermosetting polyester powdercoat. UV, chip, and flake resistant.
3. Test Results:
   a. Gloss Consistency, Gardner 60 Degrees, ASTM D 523: Plus or minus 5 percent from standard.
   b. UV Resistance, Color and Gloss, ASTM G 155, Cycle 7: Delta E less than 2 at 2.0 mils and less than 20 percent loss.
   c. Cross-Hatch Adhesion, ASTM D 3359, Method B: 100 percent pass.
   d. Flexibility Test, Mandrel, ASTM D 522: 3 mm at 2 mils.
   e. Erichsen Cupping, ISO 1520: 8 mm.
   f. Impression Hardness, Buchholz, ISO 2815: 95.
   g. Impact Test, ASTM D 2794: 60 inch-pounds at 2.5 mils.
   h. Pencil Hardness, ASTM D 3363: 2H minimum.
   i. Corrosion Resistance, 1,500-Hour Test, ASTM B 117: Max undercutting 1 mm.
   j. Humidity Resistance, 1,500-Hour Test, ASTM D 2247: Max blisters 1 mm.
4. Color: Black

PART 3 – EXECUTION

3.01 EXAMINATION

A. Verify that substrates are stable and capable of supporting the weight of items covered under this section. Notify Architect of conditions that would adversely affect installation or subsequent use. Do not begin installation until unacceptable conditions are corrected.

B. Verify that substrates have been adequately prepared to securely anchor those items that will be surface mounted.

3.02 INSTALLATION

A. Install receptacles and benches level and plumb in locations indicated on the drawings. Anchor securely in place per manufacturer’s instructions.

B. Install in conformance to applicable ADA guidelines and End User’s established Accessibility Policies.

3.03 ADJUSTING

A. Finish Damage: Repair minor damages to finish in accordance with manufacturer’s instructions and as approved by Architect.

B. Component Damage: Remove and replace damaged components that cannot be successfully repaired as determined by Architect.

3.04 CLEANING

A. Clean benches and receptacles promptly after installation in accordance with manufacturers' instructions.

B. Do not use harsh cleaning materials or methods that could damage finish.

3.05 PROTECTION

A. Protect installed litter receptacles and benches to ensure that, except for normal weathering, receptacles will be without damage or deterioration at the time of Substantial Completion.

END OF SECTION 32 33 00

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SECTION 32 33 01

PRIVATE PROPERTY DEMOLITION AND RESTORATION

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for demolishing and restoring private property impacted by the Work at the following locations:

1. 461 S. Capitol Avenue (Don’s Investments Property)
2. 1091 S. Capitol Avenue (Tran Property)
3. 2695 Story Road (World Oil Property)
4. 2690 Story Road (Autozone Property)
5. 2710 Story Road (Chevron Property)
6. 1148 S. Capitol Avenue (S&S Market Property)
7. County Airport Property at Capitol Expressway/Cunningham Avenue

1.02 RELATED SECTIONS

A. Section 01 78 39, Project Record Documents .

B. Section 02 41 00, Demolition .

C. Section 02 41 10, Structure Demolition for structure Demolition at 1091 S. Capitol Avenue is .

D. Section 02 61 00, Contaminated Soil Management .

E. Section 31 00 00, Earthwork.

F. Section 31 23 19, Dewatering.

G. Section 32 12 16, Asphalt Paving.

H. Section 32 16 00, Curbs, Gutters, Sidewalks and Driveways, for concrete restoration.

I. Section 32 17 14, Traffic Stripes, Pavement Markings and Pavement Markers.

J. Section 32 31 13, Chain Link Fences and Gates.

K. Section 32 84 00, Planting Irrigation.

L. Section 32 93 00, Planting, for landscape demolition and restoration.

M. Section 33 31 00, Sanitary Sewerage Piping.

N. Section 33 40 00, Storm Drain Utilities.

1.03 REFERENCED STANDARDS

A. State of California, Department of Transportation (Caltrans), Standard Specifications 2018:

1. Section 83, Railings and Barriers

B. County of Santa Clara, Roads & Airports Department, Standard Specifications May 2000, and Standard Specifications Amendments January 7, 2011

C. City of San Jose, Department of Public Works, Standard Specifications July 1992.

1. Section 1305, Pipeline Structures

D. San Jose Water Standard Details

1.04 SUBMITTALS

A. General: Refer to Special Conditions for submittal requirements and procedures.

B. Sign Product Data: Submit product data for the following:

1. Concrete Mix Design
2. Posts
3. Building Material
4. Hardware
5. Sign Shop Drawings

C. 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.

1.05 MEASUREMENT AND PAYMENT

A. Measurement: Only items listed in Bid List will be measured for payment.

1. Property Demolition and Restoration (461 S. Capitol Ave) shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

2. Property Demolition and Restoration (1091 S. Capitol Ave) shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

3. Property Demolition and Restoration (2695 Story Road) shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

4. Property Demolition and Restoration (2690 Story Road) shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

5. Property Demolition and Restoration (2710 Story Road) shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

6. Property Demolition and Restoration (1148 S. Capitol Avenue) shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

7. Property Demolition and Restoration (Airport Property) shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

8. The limits for payment for demolition shall be the area bounded by the existing public right-of-way line and the work on the private property.

9. The limits for payment for restoration shall be the area bounded by the proposed public right-of-way line and the work on the private property.

B. Payment: Only items listed for in the Bid Item list will be paid in accordance with the bid list.

1. The lump sum payment for Property Demolition and Restoration (461 S. Capitol Ave) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in demolishing and restoring the property located at 461 S. Capitol Ave, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

2. The lump sum payment for Property Demolition and Restoration (1091 S. Capitol Ave) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in demolishing and restoring the property located at 1091 S. Capitol Ave, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

3. The lump sum payment for Property Demolition and Restoration (2695 Story Road) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in demolishing and restoring the property located at 2695 Story Road, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

4. The lump sum payment for Property Demolition and Restoration (2690 Story Road) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in demolishing and restoring the property located at 2690 Story Road, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

5. The lump sum payment for Property Demolition and Restoration (2710 Story Road) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in demolishing and restoring the property located at 2710 Story Road, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

6. The lump sum payment for Property Demolition and Restoration (1148 S. Capitol Avenue) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in demolishing and restoring the property located at 2710 Story Road, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

7. The lump sum payment for Property Demolition and Restoration (Airport Property) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in demolishing and restoring the property

located at Airport Property, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 SIGN MATERIAL

A. Coordinate with property owners for signage salvage and restoration. At minimum, signs shall be equivalent materials of existing signs.

PART 3 – EXECUTION

3.01 GENERAL REQUIREMENTS

A. Coordinate with property owner for access to property.

B. Perform property demolition in conformance with Section 02 41 00, Demolition.

C. Perform contaminated soil management in conformance with Section 02 61 00, Contaminated Soil Management.

D. Excavate and backfill sites in conformance with Section 31 00 00, Earthwork.

E. Dewater site and excavations in conformance with Section 31 23 19, Dewatering.

F. Place Asphalt Paving in conformance with Section 32 12 16, Asphalt Paving.

G. Construct concrete improvements in conformance with Section 32 16 00, Curbs, Gutters, Sidewalks and Driveways.

H. Secure sites with temporary chain link fencing in conformance with Section 32 31 13, Chain Link Fences and Gates.

I. Restore irrigation and landscaping in conformance with Section 32 84 00, Landscape Irrigation and Section 32 93 00, Planting. Coordinate with property owner for final improvements.

3.02 461 S. CAPITOL AVENUE (DON'S INVESTMENT PROPERTY)

A. Coordinate with property owner for fire service rearrangement. Perform work in conformance with San Jose Water Company Standards. Restore area in conformance with this Section.

B. Grade site and construct storm drain improvements in conformance with Section 33 40 00, Storm Drain Utilities.

3.03 1091 S. CAPITOL AVENUE (TRAN PROPERTY)

A. Perform structure demolition in conformance with Section 02 41 10, Structure Demolition.

B. Final grade site after structure demolition. Secure site with chain link fence and gate in conformance with Section 32 31 13, Chain Link Fences and Gates.

3.04 2695 STORY ROAD (WORLD OIL PROPERTY)

A. Remove and Salvage private property signage as shown on the Plans. Completely remove existing foundation and associated facilities. Coordinate salvage location and new sign locations with Engineer and property owner.

B. Remove and Salvage air and water station. Completely remove existing foundation and associated facilities. Coordinate salvage location and new station location with Engineer and property owner.

C. Install backflow preventer in conformance with San Jose Water Company Standard Details. Coordinate backflow preventor location with Engineer and property owner. Reconnect to private property water supply.

D. Install sanitary sewer cleanout in conformance with City of San Jose Standard Specifications Section 1305, Pipeline Structures, and the requirements of Section 33 31 00, Sanitary Sewerage Utilities. Coordinate cleanout location with Engineer and property owner. Reconnect to private property sewer system.

3.05 2690 STORY ROAD (AUTOZONE PROPERTY)

A. Grade site and construct storm drain improvements in conformance with Section 33 40 00, Storm Drain Utilities.

B. Construct ramp and railing in conformance with Section 32 16 00, Curbs, Gutters, Sidewalks and Driveways and Caltrans Standard Specifications Section 83, Railings and Barriers.

3.06 2710 STORY ROAD (CHEVRON PROPERTY)

A. Remove and Salvage private property signage as shown on the Plans. Completely remove existing foundation and associated facilities. Coordinate salvage location and new sign locations with Engineer and property owner.

3.07 1148 S. CAPITOL AVENUE (S&S MARKET PROPERTY)

A. Remove and Salvage private property signage as shown on the Plans. Completely remove existing foundation and associated facilities. Coordinate salvage location and new sign locations with Engineer and property owner.

B. Grade site and construct storm drain improvements in conformance with Section 33 40 00, Storm Drain Utilities.

C. Stripe parking lot in conformance with Section 32 17 14, Traffic Stripes, Pavement Markings and Pavement Markers. Coordinate with Engineer for final striping configuration.

3.08 AIRPORT PROPERTY

A. Remove and salvage private property signage as shown on the Plans. Completely remove existing foundation and associated facilities. Install salvaged sign on new foundation. Coordinate salvage location and installation location with Engineer and property owner.

END OF SECTION 32 33 01

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SECTION 32 35 20

SOUND BARRIER ON STRUCTURES

PART 1 - GENERAL

1.01 SUMMARY

A. The scope of work outlined in this Section includes the following items of work, as detailed in these Technical Specifications, as shown on the plans or reasonably implied therefrom and is not limited to the following items:

1. Sound barriers

1.02 RELATED SECTIONS

A. Section 6.6.2, Submittal, of the Special Conditions

B. Section 7.43, Submittal of Shop Drawings, Product Data and Samples, of the General Conditions

C. Section 03 05 15, Portland Cement Concrete

D. Section 03 11 00, Concrete Formwork

E. Section 03 20 00, Reinforcing Steel

F. Section 03 30 00, Cast-in-Place Concrete

1.03 REFERENCED STANDARDS

A. ASTM International (ASTM):

1.	ASTM E90	Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements
2.	ASTM E283	Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Skylights, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen
3.	ASTM E330	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

B. State of California, Department of Transportation (Caltrans), Standard Specifications 2018:

1.	Section 51	Concrete Structures
2.	Section 52	Reinforcement
3.	Section 90	Concrete

1.04 SUBMITTALS

A. General: Submittals for sound barrier must be made in accordance with Section 6.6.2, Submittal, of the Special Conditions, Section 7.43, Submittal of Shop Drawings, Product Data and Samples, of the General Conditions, and these Technical Specifications.

B. Shop Drawings: Shop Drawings must include details of sound barrier, including limits of area receiving architectural treatment and locations and opening dimensions of expansion joints.

C. Concrete Mix Designs: Submit mix designs in accordance with the requirements specified in Section 03 05 15, Portland Cement Concrete.

D. Reinforcement: Submittals must be made in accordance with the requirements of Section 03 20 00, Concrete Reinforcing.

E. Certificates of Compliance:

1. Contractor must provide Certificates of Compliance for expansion joint seal.
2. Certificates of Compliance must include the name, source, and description of all materials used and must be signed by the material supplier certifying that each material item complies with, or exceeds the specified requirements.

F. Product Data: Submit product data and manufacturer's installation instruction and recommendations for expansion joint seals.

G. Samples: Submit samples of each color and type of expansion joint seals to be used at sound barrier.

1.05 QUALITY CONTROL AND ASSURANCE

A. Codes and Standards: Comply with all Federal, State and local codes and safety regulations.

B. Inspection by VTA and Other Governing and Regulatory Authorities: Allow VTA and other governing and regulatory authorities to perform testing and inspection of materials and practices associated with construction within their jurisdiction on the Worksite during business hours for the purpose of ensuring that the Work is in compliance with the requirements of the plans, these Technical Specifications, and other local, state and federal laws and regulations.

C. Contractor Quality Control:

1. Concrete: Concrete quality control must be in accordance with the provisions of Section 03 05 15, Portland Cement Concrete, and Section 03 30 00, Cast-in-Place Concrete.
2. Concrete Reinforcing: Concrete reinforcing quality control must be in accordance with the provisions of Section 03 20 00, Concrete Reinforcing.

D. VTA Quality Assurance:

1. VTA will monitor the implementation of the Contractor's quality control programs through observation, inspection, sampling and testing in accordance with Section 6.26, Quality Assurance and Quality Control Requirements, of the Special Provisions.
2. Failure of VTA to detect work or material which is defective or contrary to these Technical Specifications must not prevent later rejection when such work or material is discovered, nor must it obligate VTA for final acceptance.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver expansion joint seals to Worksite in manufacturer's original, intact, labeled containers. Handle and protect as necessary to prevent damage or deterioration during shipment, handling and storage. Store in accordance with manufacturer's installation instructions.

1.07 MEASUREMENT AND PAYMENT

A. Measurement: Sound Barrier must be measured by the square foot.

1. The vertical height is the difference in elevation on the inside face of the sound barrier from the bottom of the sound barrier to the top of sound barrier profile. The length of the sound barriers must be measured along the inside face of the wall, with no deductions for expansion joints.

B. Payment: The contract price paid per square foot for Sound Barrier must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing sound barriers complete in place as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefor.

C. Full compensation for furnishing, placing, and installing expansion joint seals and reinforcing steel at sound barrier, including reinforcement extending from the sound barrier into the deck, curb, or retaining wall as shown on the drawings or as specified in these Technical Specifications, must be considered as included in the bid item for Sound Barrier and no additional compensation will be allowed therefor.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Concrete: Conform to applicable requirements of Section 03 05 15, Portland Cement Concrete, and Section 03 30 00, Cast-in-Place Concrete.

B. Concrete Reinforcement: Conform to applicable requirements of Section 03 20 00, Concrete Reinforcing, of grades and sizes indicated.

C. Expansion Joint Seal: Preformed, pre-compressed, self-expanding, watertight sealant system with multiple silicone-coated sealing faces in one integrated primary system.

1. Basis of Design: Seismic Colorseal-DS, as manufactured by EMSEAL Joint Systems, Ltd (Westborough, MA).
2. Expanding foam must be cellular foam impregnated with a water-based, non-drying, 100 percent acrylic dispersion.
3. Silicone Sealant: Silicone sealant for field application must be as recommended by the manufacturer of the expansion joint seal system.
4. Color of expansion joint seal product must closely match that of finished concrete. Color of silicone sealant must be clear or match color of expansion joint seal product.
5. Expansion joint seal must be capable of movements of plus 50 percent and minus 50 percent (100 percent total) of nominal material size.
6. Expansion joint seal must be capable of withstanding 150 degree Fahrenheit for three hours while compressed down to the minimum of movement capability dimension of the basis of

design product (minus 50 percent of nominal material size) without evidence of any bleeding of impregnation medium from the material.

7. After the heat stability test and after first being cooled to room temperature, the expansion joint seal must subsequently self-expand to the maximum of movement capability dimension of the basis-of-design product (plus 50 percent of nominal material size) within 24 hours at room temperature of 68 degrees Fahrenheit.
8. Sound Transmission Class (STC): Expansion joint seal must be certified by an independent laboratory test report to meet or exceed an STC 52 rating in an STC 56 wall, in accordance with ASTM E90.
9. Outdoor Indoor Transmission Class (OITC): Expansion joint seal must be certified by an independent laboratory test report to meet or exceed an OITC 38 rating in an OITC 38 wall, in accordance with ASTM E90.
10. Expansion joint seal must be certified by an independent test report to exceed the requirements of curtain wall performance tests ASTM E330, ASTM E283, and ASTM E331. Expansion joint seal must meet or exceed hurricane-force wind loading with no deflection at both positive and negative pressures up to 4954 Pascals, equal to 200 mph winds, in accordance with ASTM E330, Procedure A.
11. All products must be certified by an independent laboratory test report to be free in composition of any waxes or wax compounds using FTIR and DSC testing.

2.02 FABRICATION

A. Expansion Joint Seal:

1. Expansion joint seal must be supplied precompressed to the precompressed width shown on the plans, packaged in shrink-wrapped lengths (sticks) with a mounting adhesive on one face.
2. Select the sealant system model appropriate to the movement and design requirements at each joint location, in accordance with these Technical Specifications and as shown on the Plans.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Reinforcement for sound barrier must conform to the requirements in Section 03 20 00, Reinforcing Steel, of these Technical Specifications.

B. Concrete for sound barrier must conform to the requirements in Section 03 30 00, Cast-in-Place Concrete, of these Technical Specifications.

C. Expansion Joint Seal:

1. Install the expansion joint seal in accordance with the Manufacturers installation instructions, including the field installation of liquid silicone injection bands at the substrate-to-bellows interfaces.
2. Provide properly formed and prepared expansion joints constructed to the exact dimensions shown on the Plans.
3. Joint surfaces must be surface dry when seals are placed.
4. Ensure that there is sufficient depth to receive the full depth of the size of the expansion joint seal being installed plus at least 1/4-inch for the application of silicone corner beads at the substrate-to-bellows interface.

5. Clean concrete areas to be in contact with expansion joint seal of loose or foreign material that would prevent bonding between the expansion joint seal and the concrete surfaces immediately prior to installation of expansion joint system.
6. Repair spalled, irregular or unsound joint surfaces in accordance with Section 03 35 00, Concrete Finishing. Remove protruding roughness to ensure joint sides are smooth.
7. No drilling, or screwing, or fasteners of any type are permitted to anchor the sealant system into the substrate.
8. Protect the expansion joint seal system and its components during construction. Damage to the expansion joint system must be repaired. After work is complete, clean exposed surfaces with a suitable cleaner that will not harm or attack the finish.

3.02 FIELD QUALITY CONTROL

A. The Independent Testing Agency must inspect the expansion joint seal and notify the VTA of defects. All defects must be corrected at the expense of the Contractor.

END OF SECTION 32 35 20

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SECTION 32 84 00

PLANTING IRRIGATION

PART 1 - GENERAL

1.01 SUMMARY

A. This section includes requirements for planting irrigation.

1. Work in this section includes installation of a complete automatic irrigation system, including excavation for points of connection downstream from the water meter, trenching, piping, equipment, electrical components and incidentals related thereto.

1.02 QUALITY CONTROL

A. Standards: Unless otherwise shown or specified, all materials and methods must conform to section 20-2 of the State of California Department of Transportation Standard Specifications (DTSS) as they reasonably apply to this work except for measurement and payment requirements.

B. All irrigation must be provided and performed in accordance with the current City of San Jose and VTA Specifications and Details. Wherever these plans and the City or VTA Standards conflict, the higher quality standard or specification will apply.

C. Submittals: Submit cut sheets for all irrigation equipment specified in the contract documents.

D. Reviews: Contractor must specifically request the following reviews prior to progressing with the work:
1. Layout of system.
2. Points-of-connection excavation downstream from the water meter
3. Trenching and pipe assembly.
4. Coverage adjustment of all heads and valve box installation.
5. Operation of system.

1.03 MEASUREMENT AND PAYMENT

A. Measurement: Planting Irrigation must be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Planting Irrigation must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Planting Irrigation complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefore

PART 2 - PRODUCTS

2.01 MATERIALS

A. Quality: All materials must be new and the best quality available unless otherwise specified. All materials must be clearly marked by manufacturer on all material, containers, or certificates of contents for inspection.

B. Plastic Pipe and Fittings: All mainline pipe ¾" – 1-½" in size must be polyvinyl chloride (PVC) Schedule 40; sizes 2" and larger must be Class 315. Unless otherwise noted, all laterals must be Class 200 PVC pipe; solvent weld fittings, if used, must be Schedule 40, or Schedule 80 as called for on details. Solvent for piping must be as recommended by manufacturer. All pipe must be clearly labeled with manufacturer type and specification numbers.

C. Control Wire: Type UF, 600 v. insulation, minimum size #14, copper, common to be white, valve control wire to be red or black, U.L. approved for irrigation control use; splices must be "Scotch-Lok" seal pack, or equal.

D. Valve Boxes: Precast concrete or plastic of type and size indicated; free of all cracks, chips or structural defects. Boxes located in pavement (asphalt or concrete) and/or subject to vehicular traffic must be concrete and have heavy duty steel covers. Boxes must be sized to provide a 4" minimum clearance around the irrigation equipment inside the box, excluding all pipes and fittings.

E. Irrigation Equipment: Refer to drawings. Any desired substitutions require submittals in duplicate for specific written approval.

F. Thread Sealant: Permatex Thread Sealant, part #14H, white in color.

PART 3 - EXECUTION

3.01 **GRADING**: Contractor must be responsible for installing all irrigation features to their finished grade and at depths indicated. All rough grading must be completed before trenching commences.

3.02 **LAYOUT AND TRENCHING:** All features of the irrigation system must be staked and pipe alignments marked prior to trenching for review by the Engineer.

3.03 **BACKFILLING:** Do not cover joints until system has been reviewed by the Engineer. Backfill with damaging rocks and debris must not be permitted. Compact all backfill and eliminate settlement. Previously prepared soil is to be replaced as the top six inches of backfill.

3.04 **FABRICATION**: Snake pipe from side to side when trench exceeds thirty feet in length. All manifolds must be neat, orderly, and constructed for ease in maintenance operations. Construct manifolds to allow valve boxes to be parallel to each other and to adjacent walls, walks, curbs, and buildings. Cuts and joints must be free of burrs, smooth, and minimum in quantity. All pipe above finish grade must be galvanized unless noted otherwise.

3.05 **PIPELINES**: All pipelines shown parallel on the drawing may be installed in a common trench. Where pipelines are shown parallel or adjacent to shrub or groundcover areas, they must be installed in these areas. All changes in depth of pipe must be accomplished using 45-degree fittings.

3.06 **TESTING**: Test mainline at 125 psi for six (6) hours. Test and repair as necessary until satisfactory test conditions are obtained.

3.07 **CONTROL WIRE**: Install control wire in pipe trenches wherever practical. Tape to underside of pipe every ten feet. Loop wire every 20 feet. Splices must occur in valve boxes only and must be accomplished utilizing approved connectors. All wire must be installed below or level with the bottom of adjacent pipes. All wiring above finish grade must be enclosed in steel conduit. Splices must be installed in junction boxes.

3.08 **ADJUSTMENTS**: Adjust all heads for arc, radius, riser height, and distribution for uniform and optimum coverage. Such adjustments must include nozzle changes without additional cost to VTA.

3.09 **FINISH GRADE:** Unless otherwise noted, all heads must be set at finish grade and on double or triple swing joints as called for on drawings. The top of all valve boxes must be flush with finish grade.

3.10 **CONTROLLER**: Contractor must clearly label and sequence stations for ease in maintenance operations. Station valves to operate as they are located around the site. Fasten controller and wire conduits securely to wall of enclosure with conduit clamps and screws. Contractor must complete all forms and labels shipped with and/or attached to the controller; attach his own name, address and phone number to the controller via a permanent label; and must properly execute and file with VTA the controller and valve guarantees.

3.11 **RECORD DRAWING**: Contractor must regularly update a print of the system and any changes made to the system throughout the project. Features below ground must be indicated with at least two measurements from surface features such as walks, building, or sprinkler heads. All changes must be recorded on this plan before trenches are backfilled. The record drawing must be completed and submitted to the owner before final payment must be made for work installed.

END OF SECTION 32 84 00

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SECTION 32 93 00

PLANTING

PART 1 - GENERAL

1.01 SUMMARY

A. This section includes requirements for container plantings, mulch, and related work thereto.

1.02 QUALITY CONTROL

A. Reviews: The Contractor must specifically request the following reviews prior to progressing with the work:
1. Plant material approval
2. Plant layout
3. Finish grade
4. Substantial completion
5. Final completion

1.03 SUBMITTALS

A. Plant Material: Within thirty (30) calendar days after award of contract, Contractor must submit notice to the Engineer certifying the quantity and species of plant material ordered, the nursery supplying the material, any plant material unavailable at the time, and proposed plant substitutions. No plants must be ordered or delivered prior to written acceptance by the Engineer.

1.04 MEASUREMENT AND PAYMENT

A. Measurement

1. 24” Box Trees shall be measured by each.

2. 5 Gallon Plants shall be measured by each.

3. Mulch shall be measured by the square foot.

B. Payment:

1. The contract price paid for each 24” Box Tree must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in 24” box tree complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefore.

2.The contract price paid for each 5 Gallon Plant must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in 5 gallon plant complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefore.

3. The contract price paid per square foot for Mulch must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in mulch complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Nomenclature and Labels: Plant botanical names must conform to "Standardized Plant Names", second edition, and secondly, "A Checklist of Woody Ornamental Plants of California", Manual 32, University of California. All plants of each clone, species, and cultivar must be delivered to the site labeled with their full botanical names. Every plant species must be labeled with no less than one label for every ten plants of a species.

B. Quality: Minimum quality of all plant material must conform to prevailing published specifications of the California Association of Nurserymen and the American Association of Nurserymen's American Standard for Nursery Stock unless otherwise indicated. Additional specifications must be as indicated on the drawings.

C. Quantities: The quantities shown on the plant list and in labels are for the Engineer's use and are not to be construed as the complete and accurate limits of the contract. Contractor must furnish and install all plants shown schematically on the drawings. Any unlabelled plants must be considered as the smaller size shown for that type on the drawings.

D. Root Systems: All container-grown stock must be grown in its container for at least six months prior to its planting. Contractor must allow one percent of the quantity of plants for removal and inspection. Any plant material, within one year following the final acceptance of the project, determined by the Engineer to be defective, restricted, declining or otherwise deficient due to abnormal root growth, must be replaced by Contractor to the equal condition of adjacent plants at the time of replacement.

E. Trees: All trees must have straight trunks of uniform taper, larger at the bottom. Trunks must be free of damaged bark, with all minor abrasions and cuts showing healing tissue. Sucker basal growth and sucker lateral growth must be removed and treated to eliminate resprouting. Normal lower side branching must remain. Trees unable to stand upright without support must be rejected.

F. Health: Foliage roots and stems of all plants must be of vigorous health and normal habit of growth for its species. All plants must be free of all diseases, insect stages, burns, or disfiguring characteristics.

G. Untrue Species: All plant material, within two years following the final acceptance of the project, determined by the Engineer to be untrue to the species, clone, and/or variety specified, must be replaced by the Contractor, to the equal condition of adjacent plants at the time of replacement.

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H. Mulch: Per plans.

PART 3 - EXECUTION

3.01 GENERAL

A. Plant Material Approvals: Before planting operations commence, all or a representative sampling of plant material must be reviewed at the site by the Engineer. Defective plants installed without such review must be removed from the site upon request by the Engineer and an acceptable plant substituted in its place.

B. Layout: Only those plants to be planted in any single day must be laid out. Locations of all plants must be reviewed prior to planting. Plants installed without this review must be transplanted as directed by the Engineer.

C. Protection of Plants: Contractor must maintain all plant material in a healthy growing condition prior to and during planting operations. Contractor must be responsible for vandalism, theft and damage to plant material until the commencement of the maintenance period.

D. Root Systems: Contractor must be responsible for inspection of all root systems on plant materials. Inspection must include, but not be limited to, checking for rootbound stock, encircling roots at the perimeter of the container, girdling roots at the top surface of the rootball, and other defective root conditions. Such inspections must include the complete removal of soil from one percent of plant material containers, or at least one plant from each nursery and each plant type. Contractor must cut defective or potentially defective girdling, rootbound, and encircling roots and spread the root system into the surrounding backfill. Plants with excessively defective root systems must be rejected by the Contractor.

E. Pruning: Contractor must do no pruning without the specific approval of the Engineer. Plants pruned without approval must be replaced by the Contractor, if required.

F. Basins: Construct basins as necessary to water plants. Remove basins from all plants under a permanent irrigation system prior to final inspection and finish grade the planting area. Basins for plants to be hand-watered must remain in place. Basin bottoms must drain to berm away from plant stem.

G. Staking: All trees must be staked as drawn with stakes driven securely into existing soil aligned with the trunk and perpendicular to the direction of the prevailing winds. A minimum of two figure-eight wire and rubber tree ties required per stake.

H. Plant Pits, Backfill and Finish Grading: See Section 31 92 13, Landscape Soil Preparation for materials and installation requirements.

I. Cleanup: After completion of all operations, Contractor must remove all trash, excess soil and other debris. All walks and pavement must be swept and washed clean, leaving the entire area in a neat, orderly condition.

END OF SECTION 32 93 00

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SECTION 33 05 10

ADJUST FRAME AND COVER TO GRADE

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for adjusting existing inlet, manholes and other utility facilities to grade.

1.02 RELATED SECTIONS

A. Section 32 16 00, Curbs, Gutters, Sidewalks and Driveways.

B. Section 32 12 16, Asphalt Paving

1.03 REFERENCED STANDARDS

A. City of San Jose Standard Specifications, 1992 Edition with addenda.

B. State of California, Department of Transportation (Caltrans), Standard Specifications

1. Section 15, Existing Facilities

2. Section 90-2, Minor Concrete

1.04 MEASUREMENT AND PAYMENT

A. Measurement: Only items listed in Bid List will be measured for payment.

1. Adjust Utility Boxes To Grade shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment:

1. The contract price lump sum price paid for Adjust Utility Boxes To Grade shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in adjusting utility boxes to grade, including frames and covers or various types, excavation and backfill, and pavement restoration, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS (Not Used)

PART 3 – EXECUTION

A. Existing concrete inlets, manholes, valves, and utility boxes of various types shall be adjusted to grade where indicated on the plans.

B. Portland cement concrete used shall be minor concrete and comply with the requirements of Section 90-2, Minor , of the Caltrans Standard Specifications.

C. Adjustments of inlets and manholes shall be performed before paving and shall be limited to the area to be paved or surfaced during the working day in which the adjustments are performed. The top of inlet grade or manhole cover shall be protected from the asphalt concrete during paving operations by heavy plywood covers, steel plate covers, or by other methods approved by VTA. Excess paving material shall be removed before rolling.

D. Adjust of frames and covers, grates and grates, valve boxes, and monument boxes shall be in accordance with Section 15, Existing Facilities, of the City Standard Specifications and Section 15, Existing Facilities, of the Caltrans Standard Specifications.

E. Asphalt paving shall be restored in accordance with Section 31 12 16, Asphalt Paving.

F. Concrete paving shall be restored in accordance with these Section 32 16 00, Curbs, Gutters, Sidewalks and Driveways.

END OF SECTION 33 05 10

SECTION 33 05 28

TRENCHING AND BACKFILLING FOR UTILITIES

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for performing trenching and backfill for conduits and subsurface facilities.

1.02 RELATED SECTIONS

A. Section 6.6, Contract Data Requirements, of the Special Conditions

B. Section 7.43, Submittal Shop Drawings, Product Data, of the General Conditions

C. Section 31 00 00, Earthwork

D. Section 31 23 19, Dewatering

E. Section 31 23 43, Structure Excavation and Backfill

1.03 REFERENCED STANDARDS

A. American Society for Testing and Materials (ASTM):

1. ASTM C33 Standard Specification for Concrete Aggregates

2. ASTM D2922 Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods

B. State of California, Department of Transportation (Caltrans), Standard Specifications

1. Section 96 Geosynthetics

C. State of California, Department of Transportation (Caltrans), Office of Structure Construction, Trenching and Shoring Manual

D. County of Santa Clara, Roads & Airports Department, Standard Specifications May 2000, and Standard Specifications Amendments January 7, 2011

E. City of San Jose, Department of Public Works, Standard Specifications July 1992.

1.04 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, Chapter 4, Subchapter 4 — Construction Safety Orders, and Subchapter 19 — Trench 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, and Appendix Chapter 33, Excavation and Grading, for protection of the public.

1.05 SUBMITTALS

A. Refer to Section 6.6, Contract Data Requirements, of the Special Conditions, and Section 7.43, Submittal Shop Drawings, Product Data, and Samples, of the General Conditions, for submittal requirements and procedures.

B. Shop Drawings:

1. Submit shop drawings and supporting calculation for trench excavations and support systems of 5 feet or more in depth. All such submittals shall be prepared, sealed, and signed by a professional civil or structural engineer currently registered in the State of California.

C. Product Data:

1. Submit source, gradation, R-value, sand equivalent, and durability for the proposed bedding and backfill material

1.06 REGULATORY REQUIREMENTS

D. Regulatory requirements that govern he work of this Section include the following governing codes:

1. California Code of Regulations (CCR), Title 8, Chapter 4, Subchapter 4 - Construction Safety Orders, for trench and 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.

1.07 MEASUREMENT AND PAYMENT

A. Measurement:

1. Trenching and backfilling for utilities will not be measured separately for payment.

B. Payment:

1. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 – PRODUCTS

2.01 BEDDING AND BACKFILLING MATERIALS

A. Bedding, for all trenches unless otherwise specified:

1. Sand: Sand for bedding of pipe in utility trenches shall be 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, if convenient, provided the sand is clean and does n to contain deleterious substances in excess of the amounts specified in ASTM C33, Table 3.

a. Only sand will be permitted for bedding of concrete pipe, clay pipe, and cast-iron pipe.

2. Pea Gravel: Clean and graded, washed river-run gravel, ASTM C33, Size No. 7. Pea gravel may be used in trenches requiring additional drainages and for backfilling above the pipe's upper half (above the horizontal centerline).

3. Bedding for San Jose Municipal Water installation:

a. Conform to the requirements of Section 101-3.03A, Bedding Types, of the City of San Jose Standard Specifications.

4. Bedding for City of San Jose storm and sewer installation:

a. Conform to the requirements of Section 1301, Trench Excavation, Bedding and Backfill, of the City of San Jose Standard Specifications, Class 1 bedding material.

B. Backfill, for all trenches unless otherwise specified:

1. Backfill for excavations and trenches under structures and paving shall be Structure Fill as indicated, refer to Section 31 23 43, Structure Excavation and Backfill, for requirements. Common Fill will be permitted only for backfilling of excavations and trenches in open areas and landscaped areas.

2. Bedding for San Jose Municipal Water installation:

a. Conform to the requirements of Section 101-3.03A, Bedding Types, and Section 1301, Trench Excavation, Bedding and Backfill, of the City of San Jose Standard Specifications.

5. Bedding for City of San Jose storm and sewer installation:

a. Conform to the requirements of Section 1301, Trench Excavation, Bedding and Backfill, of the City of San Jose Standard Specifications.

C. Slurry Cement Backfill: Slurry cement backfill shall consist of a fluid, workable mixture of Portland cement, clean and graded aggregate, and water. Refer to City and County Standard Specifications for requirements.

D. Filter Fabric: Filter fabric shall conform to the requirements of Section 96, Geosynthetics, of the Caltrans Standard Specifications.

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 31 00 00, Earthwork for requirements.

3.03 TRENCHING AND EXCAVATING

A. Comply with CCR, Title 8, Trench Construction Safety Orders, and the California Building Code, Chapter 33, Excavation and Grading, as applicable.

B. Perform trenching and excavating as indicated and required for drainage and utility piping, conduits, and related structures, and provide shoring, bracing, pumping, and planking as required.

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, cut pavement on the neat lines at the width indicated for the trench. Pavement shall be saw cut. After compacting the backfill, restore pavement to a condition equivalent to that existing at the start of construction. Restore pavement damaged outside the neat lines.

a. Where indicated or required by the governmental authority having jurisdiction, provide slurry cement backfill for trench excavation to underside of pavement.

F. 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.

G. 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 or pea gravel, compacted to at least 90 percent relative compaction.

H. 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.

I. Bell holes shall be accurately placed and shall not be larger than required to make the joint.

J. Excavations for structures shall conform to applicable requirements of Section 31 23 43, Structure Excavation and Backfill.

3.04 BEDDING AND BACKFILLING

A. Material for bedding for all trenches unless otherwise specified shall be sand. Minimum thickness of sand bedding under concrete, clay, and cast-iron 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.

a. 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. Provide bedding and backfill for San Jose Municipal Water facilities that conform to the City of San Jose Standard Specifications.

C. Provide bedding and backfill for City of San Jose storm and sewer facilities that conform to the City of San Jose Standard Specifications.

D. Backfilling structures shall conform to the applicable requirements of Section 31 00 00, Earthwork.

E. Backfilling for site electrical conduits and ductbanks shall conform the details shown on the Contract Drawings and as specified in the Caltrans Standard Specifications.

3.05 FIELD QUALITY CONTROL AND ASSURANCE

A. Refer to Section 6.30, Compliance and Testing for Highway and Transit Pavement, and Section 7.49, Certificates of Compliance and Testing, for requirements.

B. Compaction testing of related earthwork shall be performed in accordance with applicable requirements of Section 31 00 00, Earthwork.

C. Contractor Quality Control: The Quality Control Testing Firm shall perform the following inspections and testing:

a. Density and relative compaction per ASTM D2922. Testing frequency shall be not less than one test for every 1,000 square feet of trench, per layer or lift.

D. Engineer Quality Assurance:

a. The Engineer will monitor the implementation of the Contractor’s quality control programs through observation, inspection, sampling and testing.

b. 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.

END OF SECTION 33 05 28

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SECTION 33 05 45

PIPE CASINGS AND SLEEVES FOR UTILITIES

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for installation of steel casings and sleeves installed by trenching or bore and jack method as shown on the Contract Drawings.

1.02 RELATED SECTIONS

A. Section 6.6, Contract Data Requirements, of the Special Conditions

B. Section 7.43, Submittal Shop Drawings, Product Data, and Samples, of the General Conditions

1.03 REFERENCED STANDARDS

A. American Society of Testing and Materials (ASTM):

1. ASTM A53/A53M — Standard Specification for Pipe, Steel, Blake and Hot-Dipped, Zinc-Coated, Welded and Seamless

B. American Water Works Association (AWWA):

1. ANSI/AWWA C200 — Steel Water Pipe 6 in. and Larger
2. ANSI/AWWA C206 — Field Welding of Steel Water Pipe
3. ANSI/AWWA C213 — Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines
4. ANSI/AWWA C214 — Tape Coating Systems for the Exterior of Steel Water Pipelines

C. American Petroleum Institute (API):

1. ANSI/API Specification 5L — Specification for Line Pipe

1.04 REGULATORY REQUIREMENTS

A. California Code of Regulations (CCR), Title 24, Part 2, California Building Code

1. Chapter 22, Steel
2. Chapter 22A, Steel

1.05 SUBMITTAL

A. Refer to Section 6.6, Contract Data Requirements, of the Special Conditions and Section 7.43, Submittal Shop Drawings, Product Data, and Samples, of the General Conditions for submittal requirements and procedures.

B. Product Data:

1. Submit manufacturers' product data for pipe casings (including hardware, angles, joints, clamps), vents, casing seals, casing spacers, bedding and backfill materials.

1.06 QUALITY ASSURANCE

A. Inspection by City and other Governing and Regulatory Authorities: Contractor shall allow the VTA and other governing and regulatory authorities to perform testing and inspection of materials and practices associated with construction within their jurisdiction on the Work site during business hours for the purpose of ensuring that the Work is in compliance with requirements of the City code and other local, State and Federal laws and regulations.

B. Sampling, Testing and Inspection:

1. The Contractor's approved independent testing laboratory shall perform sampling, testing, and inspections in accordance with the provisions herein and Section 6.30, Compliance and Testing for Highway and Transit Pavement, and Section 7.49, Certificates of Compliance and Testing.

2. Cooperate with and notify the VTA at least 48 hours in advance of sampling, tests and inspections being performed by the independent testing laboratory. The VTA may elect to observe these procedures. Provide samples and facilities for inspection to the VTA without extra charge if requested.

3. The independent testing laboratory shall collect samples of materials for testing in accordance with the provisions outlined herein and as directed by the VTA.

1.07 MEASUREMENT AND PAYMENT

A. Measurement: Only items listed in the Schedule of Quantities and Prices will be measured for payment.

1. Steel Casing (4") shall be measured by the Lineal Foot, horizontally along the center line of the casing.

2. Steel Casing (12") shall be measured by the Lineal Foot, horizontally along the center line of the casing.

3. Steel Casing (16.75") shall be measured by the Lineal Foot, horizontally along the center line of the casing.

4. Steel Casing (24") shall be measured by the Lineal Foot, horizontally along the center line

of the casing.

B. Payment:

1. The contract price paid per linear foot for Steel Casing (4") shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in furnishing and installing steel casing, complete in place, including trench excavation and backfill, and pavement removal and restoration, as shown on the Plans, as specified in these Technical Specifications, and as directed by the VTA.

2. The contract price paid per linear foot for Steel Casing (12") shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in furnishing and installing steel casing, complete in place, including trench excavation and backfill, and pavement removal and restoration, as shown on the Plans, as specified in these Technical Specifications, and as directed by the VTA.

3. The contract price paid per linear foot for Steel Casing (16.75") shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in furnishing and installing steel casing, complete in place, including trench excavation and backfill, and pavement removal and restoration, as shown on the Plans, as specified in these Technical Specifications, and as directed by the VTA.

4. The contract price paid per linear foot for Steel Casing (24") shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in furnishing and installing steel casing, complete in place, including trench excavation and backfill, and pavement removal and restoration, as shown on the Plans, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 PRODUCTS AND MANUFACTURERS

A. Steel casing shall conform to the requirements in ANSI/AWWA C200; ASTM A53/A53M, Grade B, or ANSI/API Specification 5L, Grade B or Grade X42.

B. Steel used for the manufacture of the casing shall be made by either the open hearth or electric furnace process.

C. Field welding shall be performed in conformance with the requirements in ANSI/AWWA C206.

D. After the casing has been fabricated and welded into lengths, it shall be thoroughly cleaned of dirt, oil, grease, loose scale and other foreign material.

E. Exterior surfaces of steel casings shall be cleaned and coated in conformance with the requirements in ANSI/AWWA C213 or at the option of the Contractor, cleaned, primed, and coated in accordance with specifications of ANSI/AWWA C214, prior to shipping.

F. Wrapping tapes for pipe in contact with the ground shall be a pressure sensitive polyvinyl chloride or polyethylene tape having thickness of 2 inches, minimum.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Steel casing shall be installed in such a manner that it is not electrically connected to, or in direct physical contact with other metal pipe. When steel casing is mechanically connected to public utility lines or to another metal pipe line, electrically insulated connections shall be used. If the other pipe is non metallic, electrically insulated connections will not be required. Electrically insulated connections shall be placed in steel casing within 5 feet of its ingress into or egress from any building or structure.

B. Tolerances: pipe casing and sleeves shall be installed true to line and grade. The tolerance for pipe slopes is 0.005 +/-.

C. Wrapping and coating pipe: Damaged coating on steel pipe casing in contact with earth shall be wrapped as follows:

1. Pipe to be wrapped shall be thoroughly cleaned and primed as recommended by the tape manufacturer.

2. Tapes shall be tightly applied with 1/2 uniform lap, free from wrinkles and voids to provide not less than a 4 inches thickness.

3. Field joints and fittings for wrapped pipe shall be covered by double wrapping 2 inch thick tape. Wrapping at joints shall extend a minimum of 6 inches over adjacent pipe coverings. Width of tape for wrapping fittings shall not exceed 2 inches. Adequate tension shall be applied so tape will conform closely to contours of joint.

D. Where a welded steel pipe casing passes through the abutment wall and at cradle locations, the welded steel pipe casing shall be additional wrapped with 2 layers of 15 pound asphalt-felt building paper, securely taped or wired in place.

3.02 FIELD QUALITY CONTROL

A. Contractor Quality Control:

1. Cooperate with and notify the VTA at least 48 hours in advance of sampling, test and inspections, being performed by the Independent Testing Agency. The VTA may elect to observe these procedures.

2. Inspections: The Independent Testing Agency shall perform the following inspections:

    a. Inspection of casings and sleeves embedded in concrete shall be performed prior to any concrete placement.

B. VTA Quality Assurance:

    a. The VTA will monitor the implementation of the Contractor's quality control programs through observation, inspection, sampling and testing.

END OF SECTION 33 05 45

SECTION 33 10 00

WATER UTILITIES

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for water systems including but not limited to the following.

1. Domestic water service
2. Fire water service
3. Fire hydrants

1.02 RELATED SECTIONS

A. Section 6.6, Contract Data Requirements, of the Special Conditions

B. Section 7.43, Submittal Shop Drawings, Product Data, and Samples, of the General Conditions

C. Section 31 00 00, Earthwork

D. Section 31 05 28, Trenching and Backfilling for Utilities

E. Section 32 12 16, Asphalt Paving

1.03 REFERENCED STANDARDS

A. American Society of Testing and Materials (ASTM):

1. ASTM B88 Standard Specification for Seamless Copper Water Tube

B. State of California, Department of Transportation (Caltrans), Standard Specification

2. Section 64 Plastic Pipe

C. City of San Jose Standard Specifications, 1992 Edition with addenda.

D. City of San Jose Standard Details, 1992 Edition

E. American Water Works Association (AWWA):

1. AWWA C151 Ductile Iron Pipe, Centrifugally Cast

1.04 SUBMITTALS

A. Refer to Section 6.6, Contract Data Requirements, of the Special Conditions, and Section 7.43, Submittal Shop Drawings, Product Data, and Samples, of the General Conditions, for submittal requirements and procedures.

B. Shop Drawings:

1. Submit detailed working drawings, manufacturers' product data and details for all water lines, valves, hydrants, meter boxes and valve boxes.

C. Certificate Of Compliance for:

1. Pipe
2. Valves
3. Hydrants
4. Valve Boxes
5. Liquid Chlorine or Hypochlorates for Disinfecting

1.05 MEASUREMENT AND PAYMENT

A. Measurement: Only items listed in the Schedule of Quantities and Prices will be measured for payment.

1. 1" Water Service shall be measured per Unit.
2. 2" Water Service shall be measured per Unit.
3. 6" Fire Water Service and Hydrant shall be measured per Unit.

B. Payment:

1. The contract price paid per unit for 1" Water Service shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in constructing water service, complete in place, including coordination with San Jose Municipal Water, testing, copper tubing and pipe, fittings, valves and boxes, connecting to new or existing facilities, service clamps, corporations stops, water meters and boxes, sleeves and casing, tracer wires, thrust blocks, trench excavation and backfill, and pavement removal and restoration, as shown on the Plans, as specified in these Technical Specifications, and as directed by the VTA.

2. The contract price paid per unit for 2" Water Service shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in constructing water service, complete in place, including coordination with San Jose Municipal Water, testing, copper tubing and pipe, fittings, valves and boxes, connecting to new or existing facilities, service clamps, corporations stops, water meters and boxes, sleeves and casing, tracer wires, thrust blocks, trench excavation and backfill, and pavement removal and restoration, as shown on the Plans, as specified in these

Technical Specifications, and as directed by the VTA.

3. The contract price paid per unit for 6" Fire Water Service and Hydrant shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing fire water service and hydrant, complete in place, including coordination with San Jose Municipal Water, testing, new pipe, fittings, valves, valve boxes, thrust and anchor blocks, hydrant assemblies, tracer wires, thrust blocks, connection to existing or new facilities, excavation and structure backfill, and pavement removal and restoration, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA

4. Sterilizing and flushing water lines, and testing as specified in the City of San Jose Standard Specifications will not be measured and paid for separately and will be considered as included in the various contract items of work, and no additional compensation will be allowed therefor.

5. Full compensation for sawcutting and removing existing improvements, and restoration of curb, gutter, sidewalk and other features shall be considered as included in the various contract items of work and no additional compensation will be allowed therefor.

PART 2 – PRODUCTS

2.01 PIPES AND FITTINGS

A. Copper tube and fittings shall be Type K Soft conforming to ASTM B88.

B. Ductile iron pipe and fittings shall be in conformance with AWWA C151 minimum thickness Class 50.

C. Polyvinyl chloride (PVC) pipe and fittings shall be Schedule 80 and shall be in conformance with the provisions of Section 64, Plastic Pipe, of the Caltrans Standard Specifications.

2.02 VALVES AND VALVE BOXES

A. Valves shall conform to requirements of Section 102-2, Valves, of the City of San Jose Standard Specifications and City of San Jose Standard Details.

B. Valve boxes shall conform to Section 103-2, Materials and Fabrication, of the City of San Jose Standard Specifications and City of San Jose Standard Details.

2.03 WATER METER AND BOXES

A. Meter boxes shall conform to Section 103-2, Materials and Fabrication, of the City of San Jose Standard Specifications and City of San Jose Standard Details.

B. Contractor shall furnish and install meter boxes. Contractor shall make arrangements with the San Jose Municipal Water for furnishing and installing water meters.

2.04 FIRE HYDRANTS

A. Fire hydrants shall conform to Section 102-3, Hydrants, of the City of San Jose Standard Specifications and City of San Jose Standard Details.

PART 3 – EXECUTION

3.01 PREPARATION

A. Locate existing facilities, posthole, and maintain existing utilities as specified in Section 31 00 00, Earthwork, and as indicated on the plans.

B. Excavations in which products will be buried shall be dry.

C. Obtain approvals from City of San Jose Fire Marshall seven days prior to any construction affecting fire services and fire hydrants.

3.02 INSTALLATION

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 minimum unless otherwise indicated or approved by the VTA.

C. Backfill around sides and to 6 inches above pipe with cover fill tamped in place and compacted to 95 percent relative density.

D. Test pipe distribution system and place tracer wire on top of pipe prior to covering pipe.

E. Backfill trench in accordance with Section 33 05 28, Trenching and Backfilling for Utilities.

F. Provide concrete thrust blocks for elbows, tees, valves, and appurtenances of buried piping in accordance with City of San Jose Standard Details.

G. Install pipe to allow for expansion and contraction without stressing pipe or joints.

H. Install unions at each connection to valves, both sides of each valve.

I. Make change in line with fittings. Do not spring joints to effect change of directions.

J. 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.

K. For connection to existing pipe, provide pipe with suitable ends of adapters, after verification of size and type of existing pipe.

L. Install tie rods and pipe clamps at every joint fitting and valve.

M. Install valves in accordance with the valve manufacturers' installation instructions.

N. Center and plumb valve box over valve. Set box cover flush with finished grade.

O. 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.

P. 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 TESTING REQUIREMENTS

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.

1. Testing and Flushing of Potable Water System: Test the potable water system 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. Repair leaks and retest the system until the system is leak free. Use testing instruments calibrated by a qualified laboratory in accordance with Section 6.30, Compliance and Testing for Highway and Transit Pavement, and Section 7.49, Certificate of Compliance and Testing. Test sequence shall be as follows:

a. Lines shall be fully flushed.

b. Lines shall be hydrostatically tested.

c. Lines shall be fully flushed.

d. Lines shall be fully disinfected.

3.04 SYSTEM DISINFECTION

A. Disinfecting and pressure testing of water lines shall conform to Section 104, Disinfecting and Pressure Testing, of the City of San Jose Standard Specifications.

END OF SECTION 33 10 00

SECTION 33 31 00

SANITARY SEWERAGE PIPING

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for sanitary sewer systems, including but not limited to sanitary sewerage piping, cleanouts and manholes.

1.02 RELATED SECTIONS

A. Section 6.6, Contract Data Requirements , of the Special Conditions

B. Section 7.43, Submittal of Shop Drawings, Product Data, and Samples, of the General Conditions

C. Section 02 41 00, Demolition

D. Section 31 00 00, Earthwork

E. Section 31 23 43, Excavation and Bedding

F. Section 33 05 28, Trenching and Backfilling for Utilities

G. Section 32 12 16, Asphalt Paving

H. Section 33 05 10, Adjust Frame and Cover to Grade

1.03 REFERENCED STANDARDS

A. American Society for Testing and Materials (ASTM):

1. ASTM C12 Standard Practice for Installing Vitrified Clay Pipe Lines
2. ASTM C150 Standard Specification for Portland Cement
3. ASTM C425 Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings
4. ASTM C478 Standard Specification for Circular Precast Reinforced Concrete Manhole Sections
5. ASTM C700 Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated

B. City of San Jose Standard Specifications, 1992 Edition with addenda.

C. State of California, Department of Transportation (Caltrans), Standard Specifications

1. Section 65, Concrete Pipe
2. Section 75, Miscellaneous Metals

1.04 SUBMITTALS

A. Refer to Section 6.6, Contract Data Requirements, of the Special Conditions, and Section 7.43, Submittal of Shop Drawings, Product Data, and Samples, of the General Conditions, for submittal requirements and procedures.

B. Shop Drawings:

1. Submit shop drawings showing piping layouts, sizes, pipe and structure material types, and other pertinent features.

2. Submit shoring plans for trench excavation

3. Submit video tapes of sanitary sewer inspections and written logs in City of San Jose Standard Television format to the VTA for review.

1.05 MEASUREMENT AND PAYMENT

A. Measurement: Only items listed in Bid List will be measured for payment.

1. Remove Sanitary Sewer Pipe shall be measured by the Lineal Foot.

2. Remove Sanitary Sewer Manhole shall be measured per Unit.

3. Adjust Sanitary Sewer Manhole to Grade shall be measured per Unit.

4. Sanitary Sewer Manhole shall be measured per Unit.

5. Sanitary Sewer Cleanout shall be measured per Unit.

6. Sanitary Sewer Pipe (6" DIP) shall be measured by the Lineal Foot.

7. Sanitary Sewer Pipe (8" VCP) shall be measured by the Lineal Foot.

8. Sanitary Sewer Pipe (12" VCP) shall be measured by the Lineal Foot.

9. Sanitary Sewer Pipe (27" VCP) shall be measured by the Lineal Foot.

B. Payment:

1. The contract price paid per linear foot for Remove Sanitary Sewer Pipe shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in removing sanitary sewer pipe of various sizes and types, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

2. The contract price paid per unit for Remove Sanitary Sewer Manhole shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in removing sanitary sewer manholes, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

3. The contract price paid per unit for Adjust Sanitary Sewer Manhole to Grade shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in adjustment of sanitary sewer manholes, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

4. The contract price paid per unit for Sanitary Sewer Manhole shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in constructing sanitary sewer manholes, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

5. The contract price paid per unit for Sanitary Sewer Cleanout shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in constructing sanitary sewer cleanouts, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

6. The contract price paid per linear foot Sanitary Sewer Pipe(6" DIP) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in constructing sanitary sewer pipe, including connections and collars, complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

7. The contract price paid per linear foot Sanitary Sewer Pipe (8" VCP) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in constructing sanitary sewer pipe, including connections and collars, complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

8. The contract price paid per linear foot Sanitary Sewer Pipe (12" VCP) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in constructing sanitary sewer pipe, including connections and collars, complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

9. The contract price paid per linear foot Sanitary Sewer Pipe (27" VCP) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in constructing sanitary sewer pipe, including connections and collars, complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

10. Abandoning sanitary sewer pipe and incidentals will not be measured separately for payment, and all costs in connection therewith shall be considered as included in the various contract items of work and no additional compensation will be allowed therefor.

11. Full compensation for sawcutting and removing existing improvements, and restoration of curb, gutter, sidewalk and other features shall be considered as included in the various contract items of work and no additional compensation will be allowed therefor.

PART 2 – PRODUCTS

2.01 BURIED PIPES AND FITTINGS

A. Vitrified Clay Pipe:

1. Pipe: ASTM C700, extra strength

2. Joints and Gaskets: Flexible compression joints and couplings conforming to ASTM C425

B. Precast Concrete Structures: ASTM C478, Portland Cement and aggregates shall conform to the provisions in Section 1207-20 of the City of San Jose Standard Specifications.

C. Cast in Place Structures: Class A with Type II modified cement in conformance with ASTM C150 or Type IP (MS) in conformance with ASTM C595.

D. Mortar Joints: Conform to the provisions in Section 65, Concrete Pipe, of the Caltrans Standard Specifications.

E. Metal Covers and Ladders:

1. Frame and cover and other miscellaneous metal components shall conform to the provisions of Section 75, Miscellaneous Metals, of the Caltrans Standard Specifications.

PART 3 – EXECUTION

3.01 PREPARATION

A. Locate existing facilities, pothole, and maintain existing utilities as specified in Section 33 00 00, Earthwork, and as indicated on the plans.

B. Remove existing sanitary sewer facilities in conflict with the work.

C. Excavations shall be free of water and extraneous material immediately before sanitary sewerage products are installed or placed. Bottoms of trenches shall have sand bedding and shall be frozen to support the bottom quadrant of the pipe and fitting.

D. Interior of pipe, pipe fittings, and cleanouts shall be cleaned of foreign substances before and after installations.

E. Existing sanitary sewer lines indicated on the plans to be removed shall remain live by providing a diversion system until the permanent system is installed and functional.

3.02 REMOVAL

A. Existing manholes and pipes, where shown on the Plans to be removed, shall be completely removed including foundation and disposed of, as specified elsewhere in these Technical Specifications, and as directed by VTA.

B. Manhole covers shall be salvaged.

C. Holes and depressions caused by the removal of existing inlets, manholes, and pipes shall be backfilled as shown on the Plans, and as specified in Section 33 05 28, Trenching and Backfilling for Utilities.

3.03 ERECTION AND INSTLLATION

A. Excavation and backfill, including bedding and compaction requirements, shall conform to Section 31 00 00, Earthwork.

B. Install products where indicated. Remove and reinstall products that are disturbed after installation. End of products to which future connections will be made shall be either 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 installation instructions.

D. 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.

E. Installation and adjustment of manholes shall conform to Section 1305, Pipeline Structures, of the City of San Jose Standard Specifications and requirements of Section 33 05 10, Adjust Frame and Cover to Grade.

F. The Contractor shall obtain the approval of the VTA prior to restoring the trench and pavement. Restore per requirements of Sections 33 05 28, Trenching and Backfilling for Utilities, and 32 12 16, Asphalt Paving.

G. Manholes for industrial waste from the elevator pits at Story Road Light Rail Station shall be coordinated with specifications for mechanical and plumbing equipment and shall be as directed by the VTA.

3.04 INSTALLING PIPE

A. Protect pipe and fittings to prevent damage.

B. Place, shape, and compact bedding material to receive barrel of pipe.

C. Start laying pipe at the lower point: lay true to line and grade indicated.

D. Install pipe to bear on bedding material along entire length with an external stainless steel sleeve.

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 the bells and grooves are on upstream end.

H. Align each section of pipe with adjoining section with uniform annular space between bell and spigot and so as 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 suitable swab or drag in pipe and pull through each joint immediately after jointing is completed.

L. Keep trenches and excavations free of water during construction and until backfilled. Backfill trench in accordance with Section 33 05 28, Trenching and Backfilling for Utilities.

M. When work is not in progress, securely plug ends of pipes and fittings to prevent extraneous matter from entering pipes and fittings.

N. Accomplish compaction by methods which will avoid damage to pipe and which will not disturb its alignment and grade. The use of vibratory rollers is prohibited until compacted cover over pipe and has reached 36 inches.

O. Connect sanitary sewerage system to existing public sanitary sewers in accordance with requirements of the City of San Jose.

3.05 TESTS

A. Sanitary sewer shall be tested in accordance with Section 1307, Acceptance Test for Sewers, of the City of San Jose Standard Specifications.

B. Conduct a ball, shuttlecock, or mandrel test to ensure that the line is free of obstructions subsequent to the placing of porous subgrade material over the line and prior to backfilling trench.

C. Upon completion of the test and determination that the line is free of obstructions, plug, cap or otherwise close the open end of ends of the installed piping to prevent the entrance of debris into the lines.

D. Immediately prior to final inspection of the work, remove debris from the portions of the sanitary sewer system installed under the Contract. 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.

E. Contractor shall perform tests required by the City of San Jose. The Contractor shall be responsible for making all necessary arrangements with the City of San Jose for witnessing the required tests.

F. Perform television inspection of new facilities.

3.06 TELEVISION INSPECTION

A. Television inspection shall comply with the provisions in Section 1307-3, Television Inspection, of the City of San Jose Standard Specifications.

B. Contractor shall perform a television inspection of the existing sanitary sewer system to determine locations of existing sewer laterals prior to start of any underground work, including excavation and drilling for piles. Contractor shall provide a video tape of the inspection to the Engineer for review. Contractor shall also accurately location on scale drawings these locations of all existing laterals to determine possible conflicts with the work.

C. Contractor shall perform a television inspection of the existing sewer system after the completion of the pile driving operations to check for damages. Contractor shall provide a video tape of the inspection to the Engineer for review. This television inspection will not be required if the Engineer determines that existing sanitary sewer facilities would not be subject to damage by the Contractor's operations.

D. Contractor shall perform a television inspection of the relocated sewer system as specified in the City of San Jose Standard Specifications.

E. Contractor is advised that approximately 50 percent of the sanitary sewer pipes are at full capacity. Contractor shall perform the necessary work to videotape in an environment allowing video recording of the entire inside of each pipe from top to invert. Videotaping shall not be completed in a submersed or partially submersed condition. This work may require that the Contractor plug the sanitary sewer pipe and pump the contents to empty the pipeline for videotaping.

END OF SECTION 33 31 00

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SECTION 33 40 00

STORM DRAINAGE UTILITIES

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for storm drainage utility.

1.02 RELATED SECTIONS

A. Section 6.6, Contract Data Requirements, of the Special Conditions

B. Section 7.43, Submittal Shop Drawings, Product Data, and Samples, of the General Conditions

C. Section 02 41 00, Demolition

D. Section 03 05 15, Portland Cement Concrete

E. Section 03 30 00, Cast-in-Place Concrete

F. Section 31 05 28, Trenching and Backfilling for Utilities

G. Section 31 23 43, Excavation and Bedding

H. Section 31 23 19, Dewatering

I. Section 32 12 16, Asphalt Paving

J. Section 33 05 10, Adjust Frame and Cover to Grade

K. Section 33 40 01, Small-Rock Slope Protection

1.03 REFERENCED STANDARDS

A. American Society for Testing and Materials (ASTM):

1. ASTM A760 Standard Specification for Pipe, Corrugated Steel, Zinc-Coated (Galvanized)
2. ASTM C12 Standard Practice for Installing Vitrified Clay Pipe Lines
3. ASTM C14 Standard Specification for Nonreinforced Concrete Sewer, Storm Drain, and Culvert Pipe
4. ASTM C76 Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
5. ASTM C425 Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings
6. ASTM C443 Standard Specification for Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets

7. ASTM C700 Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated
8. ASTM C881 Standard Specification for Epoxy-Resin-Base Bonding System for Concrete
9. ASTM D2564 Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings
10. ASTM D2729 Standard Specification for Poly (Vinyl Chloride) (PV) Sewer Pipe and Fittings

B. State of California, Department of Transportation (Caltrans), Standard Specifications

1. Division VII, Drainage Facilities
2. Section 51, Concrete Structures

C. Caltrans Standard Plans

D. City of San Jose Standard Specifications, 1992 Edition with addenda.

E. California Code of Regulations, Title 8, Division of Industry Safety, Tunnel Safety Orders, Subchapter 20.

F. Occupation Safety and Health Administration (OSHA) Regulation and Stands for Underground Construction, 29 CFR Part 1926, Subpart S, Underground Construction, and Subpart P, Excavations.

1.04 SUBMITTALS

A. Refer to Section 6.6, Contract Data Requirements, of the Special Conditions, and Section 7.43, Submittal Shop Drawings, Product Data, and Samples, of the General Conditions for submittal requirements and procedures.

B. Shop Drawings:

1. 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.

2. Provide shop drawings and written procedures describing in detail the proposed method of installation and placement of drainage pipes.

3. Provide shoring and bracing plans, calculations and details prepared by a Civil or Structural Engineer licensed in the State of California.

1.05 MEASUREMENT AND PAYMENT

A. Measurement: Only items listed in Schedule of Quantities and Prices will be measured for payment.

1. Remove Storm Drain Manhole shall be measured per Unit.

2. Remove Inlet shall be measured per Unit.

3. Abandon Storm Drain Pipe shall be measured by the Lineal Foot, along the center line of the pipe.

4. Remove Storm Drain Pipe shall be measured by the Lineal Foot, along the center line of the pipe.

5. Modified Inlet shall be measured per Unit.

6. Modified Inlet to Manhole shall be measured per Unit.

7. Adjust Storm Drain Manhole to Grade shall be measured per Unit.

8. Adjust Inlet to Grade shall be measured per Unit.

9. Overflow Inlet shall be measured per Unit.

10. Drainage Inlet (Flat Grate) shall be measured per Unit.

11. Drainage Inlet (Hooded) shall be measured per Unit.

12. Storm Drain Manhole (CSJ) be measured per Unit.

13. Storm Drain Pipe (12" RCP) shall be measured by the Lineal Foot, horizontally along the center line of the pipe.

14. Storm Drain Pipe (15" RCP) shall be measured by the Lineal Foot, horizontally along the center line of the pipe.

15. Storm Drain Pipe (18" RCP) shall be measured by the Lineal Foot, horizontally along the center line of the pipe.

16. Storm Drain Pipe (24" RCP) shall be measured by the Lineal Foot, horizontally along the center line of the pipe.

17. Storm Drain Pipe (30" RCP) shall be measured by the Lineal Foot, horizontally along the center line of the pipe.

18. Plastic Pipe (8" HDPE) shall be measured by the Lineal Foot, horizontally along the center line of the pipe

19. Concrete Protection shall be measured by the Cubic Yard.

B. Payment:

1. The contract price paid per unit for Remove Storm Drain Manhole shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in removing storm drain manhole, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

2. The contract price paid per unit for Remove Inlet shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in removing inlet, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

3. The contract price paid per linear foot for Abandon Storm Drain Pipe of various sizes and types shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals and for doing all work involved in abandoning pipe, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

4. The contract price paid per linear foot for Remove Storm Drain Pipe of various sizes and types shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in removing pipe, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

5. The contract price paid per unit for Modified Inlet shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in constructing each modified inlet complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

6. The contract price paid per unit for Modified Inlet to Manhole shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in constructing each modified inlet to manhole complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

7. The contract price paid per unit for Adjust Storm Drain Manhole to Grade shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in adjusting storm drain manholes to grade complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

8. The contract price paid per unit for Adjust Inlet to Grade shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in adjusting inlets to grade complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

9. The contract price paid per unit for Overflow Inlet shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in constructing each drainage inlet with trash capture, complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

10. The contract price paid per unit for Drainage Inlet (Flat Grate) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in constructing each drainage inlet (Flat Grate) complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

11. The contract price paid per unit for (Drainage Inlet (Hooded) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in constructing each drainage inlet (hooded) complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

12. The contract price paid per unit for Storm Drain Manhole (CSJ) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in constructing each storm drain manhole (CSJ) complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

13. The contract price paid per linear foot for Storm Drain Pipe (12" RCP) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in constructing storm drain pipes, including complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

14. The contract price paid per linear foot for Storm Drain Pipe (15" RCP) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in constructing storm drain pipes, including complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

15. The contract price paid per linear foot for Storm Drain Pipe (18" RCP) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in constructing storm drain pipes, including complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

16. The contract price paid per linear foot for Storm Drain Pipe (24" RCP) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in constructing storm drain pipes, including complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

17. The contract price paid per linear foot for Storm Drain Pipe (30" RCP) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in constructing storm drain pipes, including complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

18. The contract price paid per linear foot for Plastic Pipe (8" HDPE) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in constructing storm drain pipes, including complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

19. The contract price paid per cubic yard for Concrete Protection shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in constructing concrete protection, including complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

20. Concrete plugs, structure excavation, and backfill (including sand, controlled low strength material or slurry cement backfill), and incidentals will not be measured separately for payment, and all costs in connection therewith shall be considered as included in the Lineal Foot measurement for Abandon Storm Drain Pipe.

21. Trench excavation, bedding for pipe, backfill, pipe fittings and joints, concrete for pipe encasement, cradles, culverts, collars, and incidentals will not be measured separately for payment, and all costs in connection therewith shall be considered as included in the Lineal Foot measurement for pipes of various types.

22. Excavation, backfill, reinforcing, metal grates and frames, aprons, storm drain markers, cobblestone rock slope protection, pavement restoration to finish grade and incidentals will not be measured separately for payment, and all costs in connection therewith shall be considered as included in the per unit measurement for all inlets, manholes and concrete protection of various types.

23. Full compensation for sawcutting and removing existing improvements, and restoration of curb, gutter, sidewalk and other features shall be considered as included in the various contract items of work and no additional compensation will be allowed therefor.

PART 2 – PRODUCTS

A. Concrete Pipe:

1. Plain Pipe: ASTM Cl 4, Class 3; for pipe less than 12 inches in diameter.

2. Reinforced Pipe: ASTM C76, Class 3 and Class 5; for pipes ranging in diameter from 12 inches to 60 inches.

3. Joints and Gaskets: ASTM C443

B. Plastic Pipe:

1. Pipe: PVC pipe conforming to ASTM D2665 or ASTM D2729 for pipe up to and including 6 inches in diameter, and ASTM D2680 or ASTM D2729 for pipe larger than 6 inches in diameter.

2. Pipe: HDPE pipe shall be SDR 11 High Density Poly-Ethylene conforming to ASTM F2160 with butt welding conforming to ASTM F2620.

3. Cement: ASTM D2564.

4. Pipe Connection Requirements: Ends of pipe shall be bell-and-spigot, grooved, ship lapped, or secured with couplings, collars, or other connection fittings to assure continuous alignment of pipe and leak proof joints.

C. Concrete Structures: Refer to Section 51, Concrete Structures, of the Caltrans Standard Specifications.

1. All dome grate inlets shall include 5mm mesh wire for trash capture.

D. Bedding and Backfill Material: Refer to Section 31 23 33, Trenching and Backfilling for Utilities, and ASTM C12, for requirements.

E. Grout: Grout shall consist of a mixture of Portland cement, foaming agent, aggregate, water, fly ash, and admixtures (if needed). Portland cement shall be Type I, II, or III and shall conform to ASTM C150. Foaming agent shall be in conformance with ASTM C796. Aggregate shall be limestone screenings, fine sand, coarse sand, or other aggregates as approved by VTA. Water shall be free from deleterious substances. Fly ash shall be Class C or F and compatible with the foaming agent. Admixtures, if needed for accelerating, retarding, water reducing, or other specific properties, may be used when recommended by the foaming agent manufacturer.

F. Mortar for pipe joints, 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.

1. Mortar shall be job mixed in accordance with requirements of ASTM C270, including measurement, mixing, proportioning, and waterretention.

2. 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.

3. 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.

PART 3 – EXECUTION

A. Removal:

1. Existing drainage inlets, manholes, and pipes, where shown on the Plans to be removed, shall be completely removed including foundation and disposed of, as specified elsewhere in these Technical Specifications, and as directed by VTA.

2. Frames and grates or covers shall be salvaged.

3. Holes and depressions caused by the removal of existing inlets, manholes, and pipes shall be backfilled as shown on the Plans, and as specified in Section 31 05 28, Trenching and Backfilling for Utilities, of these technical specifications. Asphalt concrete for pavement restoration shall conform to the provisions in Section 32 12 16, Asphalt Paving, of these technical specifications.

B. Abandonment:

1. Existing culverts and storm drainage pipelines, where shown on the plans to be abandoned, shall be abandoned in place.

2. Culverts and pipelines 12" in diameter and larger, shall, at the Contractor's option, be backfilled with either sand, controlled low strength material, or slurry cement backfill conforming to the provisions in Section 19-3.02E, Slurry Cement Backfill, of the Caltrans Standard Specifications by any method acceptable to the Engineer that completely fills the pipe. Sand backfill material shall be clean, free draining, and free from roots and other deleterious substances.

3. Culverts and pipelines shall not be abandoned until their use is no longer required. The Contractor shall notify the Engineer in advance of any intended culvert or pipeline abandonment.

C. Excavation and Bedding:

1. Excavate trenches as specified in Section 31 23 33, Trenching and Backfilling or Imported

Backfilling with or without AC paving for Utilities.

2. Bedding: Provide bedding as specified in Section 31 23 33, Trenching and Backfilling. Classes of bedding are defined in ASTM C12. Use class of bedding indicated. Where pipe is to be encased in concrete, place concrete against undisturbed soil.

D. Laying Pipe:

4. 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.

5. Install clay pipe in accordance with applicable requirements of ASTM C12.

6. Place circular pipe having elliptical reinforcement with minor axis of the reinforcement in a vertical position.

7. Remove pipe that is cracked, checked, spalled, or damaged from the work.

8. Clean interior of pipe of cement, dirt, and extraneous matter as the work progresses.

E. Pipe Joints:

1. Prevent dirt from getting into pipe joints.

2. Pipe joints shall be made secure and watertight.

3. Employ appropriate equipment to draw the sections of the pipe tightly together.

4. Joints of bell-and-spigot pipe and tongue-and-groove pipe shall be filled with cement mortar so as to make a strong and watertight joint. Finish joints smooth on inside of pipe with cement mortar.

5. Inside joint recesses of pipe shall be buttered with cement mortar prior to closure of joint. After closure is made, the joint shall be pointed inside the pipe and excess mortar removed by means of an inflated swab or squeegee.

F. Backfilling:

1. Piping shall not be covered with backfill or imported backfilling material, with or without AC paving, until inspected, tested, and approved by the VTA.

2. After making up pipe joints, fill space between pipe and sides of trench with bedding sand or pea gravel half-way up the pipe. Both sides shall be filled for full width of trench at same time and carefully compacted so as to hold the pipe in its proper position.

3. After pipe has been installed, inspected, and approved, place and compact backfill as specified in Section 31 23 33, Trenching and Backfilling or imported backfilling for Utilities with or without AC paving.

G. 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 3000 psi concrete in accordance with Section 03 05 15, Portland Cement Concrete.

4. Coordinate with requirements of Section 03 05 15, Portland Cement Concrete and Section 03 30 00, Cast-in-Place Concrete for placement of pipes within structural footings.

H. Connections to Existing Drainage Structures:

1. The Contractor shall verify the invert elevations at any point where a proposed storm drainage pipe, structure, or feature connects to an existing storm drainage pipe, structure, or other existing storm drainage feature.

I. Storm Drainage Crossing with Existing Utilities:

1. Existing utilities shown on the Project plans were compiled from the Project's utilities Project plans and other sources. The type and location of the shown existing utilities shown on the Project plans may have changed and additional existing utilities might not beshown. Contractor shall field verify the type, size, and locations of existing utilities prior to installation of the proposed storm drainage utilities. Contractor shall be responsible for damage to utilities when installing storm drainage utilities caused by Contractor's negligence and shall assume liability resulting therefrom.

J. Testing:

1. Drainage facilities shall be tested in accordance with Section 1307, Acceptance Test for Sewers, of the City of San Jose Standard Specifications.

END OF SECTION 33 40 00

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SECTION 33 40 01

SMALL-ROCK SLOPE PROTECTION

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for constructing small-rock slope protection.

1.02 RELATED SECTIONS

A. Section 31 00 00, Earthwork

1.03 REFERENCED STANDARDS

A. State of California, Department of Transportation (Caltrans), Standard Specifications

1. Section 19, Earthwork

2. Section 72-4, Small-Rock Slope Protection

1.04 MEASUREMENT AND PAYMENT

A. Measurement: Small-Rock Slope Protection shall be measured by the Cubic Yard.

B. Payment: The contract price paid per cubic yard for Small-Rock Slope Protection shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing small-rock slope protection complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

A. Rock must be cobble, gravel, crushed rock, or any combination of these and comply with the requirements of Caltrans Standard Specifications Section 72-4, Small-Rock Slope Protection.

B. Granular material must contain at least 90 percent crushed particles when tested under California Test 205.

C. Cobblestone rock protection shall be 4”-6” Max cobblestone.

D. Plastic Barrier shall be 30 mils thick.

PART 3 – EXECUTION

A. Earthwork must comply with Section 31 00 00, Earthwork, and Section 19, Earthwork, of the Caltrans Standard Specifications.

B. Small-rock slope protection shall be constructed per details shown on the plans.

C. Small rock may be placed by dumping and spread by bulldozers or other suitable equipment. During installation, do not crack the rock.

END OF SECTION 33 40 01

SECTION 33 43 01

SELF-RETAINING AREA

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for self-retaining area.

1.02 RELATED SECTIONS

A. Section 31 00 00, Earthwork

B. Section 32 84 00, Planting Irrigation

C. Section 32 93 00, Planting

D. Section 33 40 00, Storm Drainage Utility

E. Section 33 40 01, Small-Rock Slope Protection

1.03 REFERENCED STANDARDS

A. State of California, Department of Transportation (Caltrans), Standard Specifications

B. California Department of Transportation Standard Plans

C. Valley Transportation Authority, Stormwater and Landscaping Design Criteria Manual, July 2019

D. City of San Jose, Department of Public Works, Standard Specifications July 2012

E. City of San Jose, Department of Public Works, Standard Details July 2012

F. County of Santa Clara, Roads & Airports Department, Standard Specifications May 2000, and Standard Specifications Amendments January 7, 2011

G. County of Santa Clara, Roads & Airports Department, Standard Details September 1997, and Amendments

1.04 MEASUREMENT AND PAYMENT

A. Measurement: Only items listed in the Bid List will be measured for payment.

1. Self-Retaining Area shall be measured by the Square Foot.

B. Payment:

1. The contract price paid per square foot for Self-Retaining Area shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for

doing all Work involved in constructing self-retaining area complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

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, grading, and other site preparation work for self-retaining area.

PART 3 – EXECUTION

A. The designated self-retaining area shall be cleared of all vegetation, such as trees, logs, upturned stumps, roots of down trees, brush, grass, weeds and other objectionable material including concrete or masonry.

B. Contractor shall construct self-retaining areas in conformance with the lines and grades established by the Engineer. When completed, the elevation and plane of the slope shall conform to the elevations and slopes indicated on the plans.

C. The side slopes which are on a 3:1 (horizontal:vertical) or flatter slope shall be finished in conformance with the line and grades established by the Engineer. The completed slopes shall not vary more than 0.2-foot from the designated slope, measured at right angles to the slope. Flowlines within the self-retaining area shall be flat and not vary more than 0.1-foot from the grade line established by the Engineer.

D. The tops of excavation slopes and the ends of excavations shall be rounded as shown on the plans.

E. Surplus excavated material shall be removed and disposed outside of the self-retaining area or as directed by the Engineer.

F. Planting for the self-retaining areas shall comply with Section 32 93 00, Planting.

G. Irrigation for the self-retaining areas shall comply with Section 32 84 00, Planting Irrigation.

END OF SECTION 33 43 01

SECTION 33 43 04

BIORETENTION AREA

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for furnishing and constructing bio-retention areas.

1.02 RELATED SECTIONS

A. Section 31 00 00, Earthwork

B. Section 32 16 00, Curbs, Gutters, Sidewalks and Driveways

C. Section 32 84 00, Planting Irrigation

D. Section 32 93 00, Planting

E. Section 33 40 00, Storm Drainage Utility

F. Section 33 40 01, Small-Rock Slope Protection

1.03 REFERENCED STANDARDS

A. State of California, Department of Transportation (Caltrans), Standard Specifications

1. Section 19, Earthwork
2. Section 21, Erosion Control
3. Section 68, Subsurface Drains

B. Valley Transportation Authority, Stormwater and Landscaping Design Criteria Manual, July 2019

C. Santa Clara Valley Urban Runoff Pollution Prevention Program

1. Guidance for Implementing Stormwater Requirements for New Development and Redevelopment Projects (C.3 Stormwater Handbook), June 2016

1.04 SUBMITTALS

A. General: Refer to Special Conditions for submittal requirements and procedures.

B. Product Data:

1. Submit product data for biofiltration soil mix, class 2 permeable material and deepened curb.
2. Submit manufacturer's product data for pipe, pipe connection materials, and cleanouts.

1.05 MEASUREMENT AND PAYMENT

A. Measurement: Only items listed in Bid List will be measured for payment.

1. Plastic Perforated Pipe (6" PVC) shall be measured by the Linear Foot, along the center line of the pipe.
2. Bioretention Cleanout shall be measured per Unit.
3. Biofilitration Soil Mix shall be measured by the Cubic Yard.
4. Class 2 Permeable Material shall be measured by the Cubic Yard.

B. Payment:

The contract unit price paid per linear foot for Plastic Perforated Pipe (6" PVC) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in constructing bioretention area complete in place, including excavation and backfilling, plastic perforated pipe, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

The contract unit price paid per unit for Bioretention Cleanout shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in constructing bioretention area complete in place, including excavation and backfilling, bio-retention cleanout, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

The contract unit price paid per cubic yard for Biofiltration Soil Mix shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in constructing bioretention area complete in place, including excavation and backfilling, bio-retention soil, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

The contract unit price paid per cubic yard for Class 2 Permeable Material for the bioretention area shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in constructing bio-retention area complete in place, including excavation and backfilling, CL 2 permeable material, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

A. Permeable material shall be Class 2 in accordance with Caltrans Standard Specifications, Section 68-2.02F(3), Class 2 Permeable Material.

B. Bioretention Soil Mix must comply with Appendix C of the SCVURPPP C.3 Stormwater Handbook.

C. Concrete for deepened curb shall comply with the requirements of Section 32 16 00, Curbs, Gutters, Sidewalks and Driveways.

D. Bioretention cleanout shall comply with the requirements of Section 33 40 00, Storm Drainage Utility.

PART 3 – EXECUTION

A. Excavate to the described grade or details shown on the plans.

B. Excavation for the bioretention area shall be classified as roadway excavation. It shall comply with these technical specifications, Section 31 00 00, Earthwork, and Section 19, Earthwork, of the Caltrans Standard Specifications.

C. Deepened curbs shall be constructed as directed on the Plans.

D. Where a portion of the existing pavement is to be removed, cut the outline of the area to be removed on a neat line and remove all unsuitable material.

E. Site preparation must comply with Section 21-2.03, Construction, of the Caltrans Standard Specifications.

F. Place bioretention soil in lifts of 8 to 12 inches and spread to a uniform thickness. Do not compact lifts.

G. Planting for the bioretention areas shall comply with Section 32 93 00, Planting.

H. Irrigation for the bioretention areas shall comply with Section 32 84 00, Planting Irrigation.

END OF SECTION 33 43 04

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SECTION 33 71 19

ELECTRICAL UNDERGROUND DUCTS, DUCTBANKS, AND MANHOLES

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for installing the PG&E electrical service to the Traction Power Substations, including but not limited to the following.

1. Trenching and Conduits

2. PG&E Enclosures

3. Connections and Inspections

1.02 RELATED SECTIONS

A. Section 6.6, Contract Data Requirements, of the Special Conditions

B. Section 7.43, Submittal Shop Drawings, Product Data, and Samples, of the General Conditions

C. Section 27 15 23, Fiber Optic System

D. Section 31 00 00, Earthwork

E. Section 31 23 19, Dewatering

F. Section 31 05 28, Trenching and Backfilling for Utilities

1.03 REFERENCED STANDARDS

A. Pacific Gas and Electric Company:

1. Electric & Gas Service Requirements (TD-7001M) 2017-2018 (PG&E Greenbook)
2. Substructure Sketch – 2220 Eastridge Loop (PM 35085597)
3. Substructure Sketch – VTA Primary Metering – TPSS#33 (PM 35085603)

1.04 SUBMITTALS

A. Refer to Section 6.6, Contract Data Requirements, of the Special Conditions, and Section 7.43, Submittal Shop Drawings, Product Data, and Samples, of the General Conditions, for submittal requirements and procedures.

B. Shop Drawings:

1. Submit detailed working drawings, manufacturers' product data and details for all enclosures and casings.

C. Submit product data for:

1. Conduits

2. Fittings and Elbows

3. Backfill material

4. Casings

D. Submit boring/drilling plan for installation of PG&E service underneath structural approach walls at Eastridge Station, if boring/drilling installation is necessary.

1.05 MEASUREMENT AND PAYMENT

A. Measurement: PG&E Electrical Services shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for PG&E Electrical Services shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in installing the PG&E Electrical Service, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefore.

PART 2 – PRODUCTS

2.01 CONDUITS

A. Conduits and fittings shall be per PG&E Greenbook standards.

2.02 TRENCH BACKFILL

A. Trench backfill material shall meet the requirements of the authority having jurisdiction, PG&E Greenbook standards, and the requirements of Section 31 05 28, Trenching and Backfilling for Utilities

2.03 ENCLOSURES

A. Enclosures shall be per PG&E Greenbook Standards.

2.04 CASINGS

A. Casings shall be per PG&E Greenbook Standards.

PART 3 – EXECUTION

3.01 PREPARATION

A. Locate existing facilities, pothole, and maintain existing utilities as specified in Section 31 00 00, Earthwork, and as indicated on the plans.

B. Trench Excavation shall be dry. If necessary, dewater in accordance with Section 31 23 19, Dewatering.

3.02 INSTALLATION

A. Excavate pipe trench in accordance with Section 33 05 28, Trenching and Backfilling for Utilities and PG&E Greenbook standards.

B. Install fiber optic conduits as shown on the Plans and in accordance with Section 27 15 23, Fiber Optic System.

C. Joint Trench piping shall be installed at a depth of 30 inches minimum unless otherwise indicated or approved by the VTA.

D. Backfill trench per PG&E Greenbook Standards and the authority having jurisdiction.

E. Test conduits prior to backfilling trench.

F. Install enclosures flush with finish grade.

G. Install conduits and casings in accordance with approved boring/drilling plan.

H. 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 TESTING REQUIREMENTS

A. Arrange for PG&E inspection with Engineer.

B. Perform mandrel tests and other PG&E standard tests per PG&E Greenbook Standards.

END OF SECTION 33 71 19

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SECTION 34 01 23

TRACK REMOVAL AND SALVAGE

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for removal, salvage, or disposal of existing track structure as indicated in the Contract drawings. Existing track structure consists of grade crossing panels, bumping posts, rails, ties, and other track materials (OTM).

B. The work of this section may require system support and testing if removal of existing track involves system equipment and components. System equipment and components include traction power, signal, and communications.

1.02 SUBMITTALS

A. The Contractor shall make all submittals in accordance with the requirements of Special Conditions SC-6 and SC-51.

B. Submit construction methods and schedules, including personnel and equipment schedules, required to accomplish the work specified herein.

C. Submit complete track material inventory forms for all salvaged and removed materials.

1.03 MEASUREMENT AND PAYMENT

A. Measurement: Track removal and salvage shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for track removal and salvage shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in track removal and salvage.

PART 2 – PRODUCTS

2.01 DUNNAGE

A. Pallets, sills, and other materials used for packaging and stacking of unused salvaged track items shall be clean, free of decay or other defects, and sufficiently sturdy for the service intended.

2.02 MARKING PAINT

A. Marking paint shall be a good quality oil-based spray marking paint or a good quality oil-based paint marker.

PART 3 – EXECUTION

3.01 METHODS AND PROCEDURES

A. Existing track shall be completely removed to the limits shown on the plans and as specified herein.

B. Existing track removal sequencing schedule shall be coordinated with VTA LRT Operation Representative.

C. Existing grade crossing panels, rails, concrete ties, tie plates, and fastening hardware, that Engineer determines to be in good condition, shall be salvaged. Continuous Welded Rail shall be cut into sections of 39 feet in length. These rails shall be hauled to and placed neatly in designated VTA storage area.

D. Existing track ballast shall be removed to expose the top surface of existing suballast.

E. Rails shall be cut at location shown on the plan with a rail saw or an abrasive cutting wheel. Rail with torch cut ends or torch cut holes will not be allowed.

F. Existing insulated joint bars and bumping posts shall be salvaged and stored on site to be relocated or reinstalled. Existing insulated joint shall be removed by cutting 7.5ft before and after the existing joint and to be replace later on by 15ft plug rail minimum. Running Rail sections less than 15 ft in length will not be allowed.

G. 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.

H. Salvaged material shall be loaded, hauled and unloaded at the designated VTA storage site. Detailed inventory shall be recorded on forms similar to sample form shown as Attachment "A" of this Section.

3.02 STORAGE OF SALVAGED TRACK MATERIALS

A. Salvaged track materials shall be sorted, delivered and properly stacked or otherwise contained as applicable, and in accordance with the following, in a neat fashion at a VTA designated storage area.

1. Salvaged rail shall be segregated by rail section and length. The bottom row shall be placed on 7 feet by 9 feet minimum timbers spaced a maximum of 10 feet apart. Between rows, 2 inch by 4 inch minimum timbers shall be placed with a maximum distance of 10 feet between them. Rail stacks shall be located in areas safely accessible by forklifts, cranes, and other equipment.

2. Concrete grade crossing panels shall be sorted by size and stacked on pallets.

3. Concrete ties with tie plates shall be sorted by and stacked in a horizontal position, braced with wooden spacer blocks so that the top surface does not contact ties loaded above. Do stack more than 6 layers.

4. Tie plates, joint bars, and fastening hardware shall be placed in 55-gallon drums. The 55-gallon drums shall have a minimum of 6 holes drilled around the perimeter of drum near the bottom to prevent the collection of water.

5. The maximum weight of any pallet with any material shall be 3000 pounds.

END OF SECTION 34 01 23

ATTACHMENT "A"
INVENTORY OF MATERIALS REMOVED, SALVAGED, STORED AND/OR REUSED

Item No.	VTA asset inventory number	Item (Descriptio n)	Location Removed	Quantity	Unit	Date Removed	Date Placed in Storage Area	Quantity Reused	Location Used	Date Used	Remarks

VTA representative ______________________________

Contractor signature______________________________

SECTION 34 11 10

TRACK INSTALLATION GENERAL REQUIREMENTS

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for trackwork installation.

1.02 DEFINITIONS

A. The use of the following terms in these Specifications and the Contract Drawings shall be interpreted as specified herein:

1. Aerial Structure – The areas secured for tracks and appurtenances made up of more or less interdependent elements and having a definite organizational pattern extending or rising high in the air.
2. Anchor Plate – A device used in embedded track to secure running rails to concrete slab at the proper track gauge to provide vertical, lateral and longitudinal restraint of the rail.
3. Approach Slab – Reinforced concrete slab located between ballasted track and ballasted bridge track to provide a transition due to differing track stiffness.
4. At Grade Road Crossing – The crossing of a railway track and a vehicular roadway at the same elevation.
5. At Grade Track Crossing – The crossing of two or more railways tracks at the same elevation. See Crossing, Diamond.
6. Ballast – An integral part of the track structure, generally composed of graded crushed stone, in which ties are embedded.
7. Bumping Post – Steel frame device placed at end of stub end tracks to prevent a moving rail vehicle from rolling off the end of track.
8. Closure Rails – The rails placed between components of special trackwork unit, such as the rails between the switch and the frog in a turnout.
9. Continuous Welded Rail (CWR) – A number of rails welded together into a continuous string.
10. Crossing – An at grade railroad crossing (diamond) where two tracks cross or intersect each other requiring special trackwork.
11. Crossover, Double – Two single crossovers that intersect between the two adjacent and generally parallel tracks forming a connection.
12. Crossover, Single – Two turnouts, with track located between the frogs and arranged to form a continuous passage between two adjacent and generally parallel tracks.

13. Crosstie – A concrete or wood structural member designed to provide vertical, lateral and longitudinal support of running and emergency guard rails.

14. Direct Fixation Track – Track constructed of rail and direct fixation rail fasteners and attached directly to a concrete surface.

15. Direct Fixation Fastener – A resilient device used to secure running rails to a concrete trackbed in direct fixation track at the proper track gauge to provide vertical, lateral and longitudinal restraints of the rail.

16. Dutchman – A temporary rail section inserted between two rail strings during the laying of CWR.

17. Emergency Guard Rail – A rail or rails installed parallel to and inside of the running rails of track to prevent derailed vehicles from departing the trackway laterally. Generally installed at locations adjacent to major structures and on bridges.

18. Fastenings – A general term applied to device used to retain the rail in place such as spring clips, insulators, etc.

19. Frog – A track device used at the intersection of two running rails to provide support for wheel treads and passageways for wheel flanges, thus permitting wheels traversing either rail to cross the other.

20. Frog Number – The number used to designate the size of a frog, and being equal to one half the cotangent of one half the frog angle or the number of units of center line length when the spread N is one unit.

21. Gauge, Track – The distance between the inside faces of running rails of a track measured at a point 5/8 inch below the top of rail of 115 RE rail or 1/2 inch (14 mm) below top of rail of Ri 59N girder rail. The standard gauge distance shall be 4 feet – 8 ½ inches.

22. Grade Crossing Track – Crossing of ballasted track and vehicular roadway at same elevation. Ballasted track is covered with prefabricated grade crossing panels.

23. Guard Rail – A rail installed parallel to and inside of the running rail of a track to hold wheels in a correct alignment to prevent their flanges from striking the points of turnout or crossing frogs.

24. Inside Rail – On curved track, the rail nearest to the curve center; the rail with the shorter radius. Also referred to as the "low rail."

25. Joint Bar – Device used to join the abutting ends of two rails of the same cross section

26. Joint Bar, Insulated – Joint bar used to arrest the flow of electric current between two rails. Standard types are bonded and non-bonded.

27. OTM – Other Track Materials are rail fastening systems components on concrete or timber ties which includes; rail clips, screw spikes, track bolts, nuts, spring washers, tie plates, tie hole plugging material, rail anchors, standard toeless joint bars, and insulated joints.

28. Outside Rails – On curved track, the rail farthest from the curve center; the rail with the longer radius. Also referred to as the "high rail."

29. Pedestrian Crossing – The crossing of a railway track and a pedestrian sidewalk at the same elevation.

30. Premium or High Strength Rail – Rail having greater hardness than standard rail for use at locations of high track wear. Premium or High Strength Rail shall be head hardened.

31. Primary Track – Revenue track considered mainline, crossovers, and pocket tracks.

32. Profile Grade Line (PGL) – The datum line that defines the vertical alignment of the track, applied at the centerline of track at the top of the rail elevation on tangent track and the top of the inside (low) rail elevation on curves.

33. Rail Anchor – A device that clamps to the base of a rail and bears against the side of a cross tie to restrain longitudinal movement of the rail.

34. Rail Fastening – A device used in track to secure running rails to track slab at the proper track gauge. It also provides proper vertical and lateral restraint of the rail.

35. Rail, Tee – The common class of steel rail design symmetrical in section and which approximately resembles an inverted letter "T."

36. Running Rails – The support rails of a track on which the vehicle wheel tread contact.

37. Lag Screw bolts – A threaded fastener for ballasted track construction that secures tie plates and special trackwork plates to timber crossties and switch ties.

38. Special Trackwork – A generic term referring to turnouts, single and double crossovers, track crossings, and other items.

39. Spike, Cut – The standard drive-in component of ballasted track construction that secures tie plates to timber crossties and switch ties (See AREMA Manual, Chapter 5, Part 2).

40. Spike, Hair Pin Spring Type – Component of ballasted track construction that secures tie plates to timber crossties.

41. Standard Drawings – Known as VTA Standard Drawings and referenced in the construction contract to convey information pertinent to track methods and track components for the purpose of supporting construction and/or procurement of track and materials.

42. Stock Rail – A running rail that a switch point rail mates against in a split switch.

43. Subballast – A material superior in composition to the subgrade material that provides a semi impervious layer between the track ballast and the subgrade to provide better drainage and distribution of loads to the subgrade.

44. Subgrade – The finished embankment or excavation below the level of subballast.

45. Superelevation – In curved track, the amount that the outside rail is raised above the inside rail. The inside rail elevation is maintained at the PGL top of rail profile.

46. Switch, Point of – The tip of the tapered end of a switch point rail; the end of a switch rail farthest from the frog.

47. Switch Point, Switch Rail – The machined movable point rail of a split switch.

48. Switch, Split – The common type of track switch consisting of two planed switch point rails and their associated stock rails and hardware.

49. Switch, Tie – Wood structural member designed to provide vertical, lateral and longitudinal support of special trackwork components.

50. Switch, Undercut – A switch in which the stock rails are undercut to mate with or nest the switch rails so that the actual point of the switch rail head does not protrude beyond the original outline of the stock rail's head outline, commonly called a Sampson switch point.

51. Tie – Crosstie or Switch Tie.

52. Top of Rail (T/R) – That portion of the running rail that follows the PGL. Top of rail elevation is measured at the centerline of the rail.

53. Track, Ballasted – Track constructed of ballast, crossties, tie plates, rails and fastenings.

54. Track Foot – Unit of measurement for all types of track construction; measured along the centerline of track.

55. Track, Primary – A revenue service track designated by route name and direction.

56. Track Crossing – An assembly of four frogs, connecting rails and guard rails that allows two single tracks to cross one another. See Crossing (Diamond).

57. Turnout – A track arrangement consisting of a switch, frog, stock rails, closure rails, and guard rails enabling rail vehicles to be diverted from one track to another.

58. Turnout Number – The number corresponding to the number of the frog used in a turnout.

59. VTAFSW – VTA Furnished Special Trackwork Materials A generic term referring to turnouts, single and double crossovers, track crossings, and other items to be furnished by VTA.

60. Working Drawings – Contractor prepared drawings to convey work plan information for the installation of the component part of the track works and/or structures.

1.03 REFERENCED STANDARDS

A. Pertinent provisions of the following listed standards and publications shall apply to the Work, except as they may be modified herein, and are hereby made part of these Specifications to the extent required.

1. American Railway Engineering and Maintenance-of-Way Association, Manual for Railway Engineering, herein referred to as the AREMA Manual.

2. American Railway Engineering and Maintenance–of-Way Association, Portfolio of Trackwork Plans, herein referred to as the AREMA Portfolio.

3. American Society for Testing and Materials (ASTM)

   ASTM E10 — Standard Method of Brinell Hardness for Metallic Materials

4. State of California, Department of Transportation (Caltrans) Standard Specifications.

1.04 SUBMITTALS

A. Submittals shall include certificates of compliance, codes and regulations of the jurisdictional authorities including other submittals as stipulated in these Specifications.

B. Manufacturer's printed instruction and shop drawings for special trackwork assembly will be supplied to the Contractor as per Section 34 11 23.

C. Submit the end-hardening procedure and a list of trained or otherwise qualified personnel who will perform the end-hardening on the rail in the field to the VTA.

D. Rail End-Hardening Submittal and Tests

E. Continuous welded rail laying records as specified in Article 3.07, Laying Continuous Welded Rail.

F. Two rail thermometers.

G. Submit the type of equipment and method of operation to VTA Representative for acceptance prior to initiation of rail grinding.

H. In order to determine the acceptability of the installation, the Contractor shall make a survey of the track and submit a copy to VTA Representative for review.

I. Submit construction equipment data and loading diagrams to VTA Representative for review.

1.05 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 – PRODUCTS

2.01 MATERIALS

A. General: Furnish all trackwork materials and incidental materials required for the construction of track.

B. Metal tags to mark the superelevation on curved track shall be made of a corrosive resistant metal such as brass or 20-gauge aluminum sheet. Tags shall be pressed or stamped in 1/4-inch increments from 0 to the maximum superelevation. Characters shall be a minimum of 3/4-inch in height. Epoxy adhesive for bonding the tags to hardened concrete shall be a 2-components epoxy resin systems of the type, grade and class specified according to current ASTM C881.

PART 3 – EXECUTION

3.01 CONSTRUCTION EQUIPMENT

A. Track gauge, guard rail, flangeway width, curve radii, rail sections, and special trackwork components are designed for Light Rail Vehicle operation. Modify on track equipment, as required, to operate over this track without causing damage to the track structure. Damages to the track structure shall be repaired by the Contractor at its expense.

B. Clearance for the on track equipment shall conform to the requirements for vehicle clearances.

C. Contractor's equipment shall not exceed the design loads. Further information concerning vehicle characteristics will be provided by VTA upon request by the Contractor.

D. The Contractor shall submit loading diagrams for construction equipment and complete calculations showing conformance with live load requirements for approval before construction equipment is allowed on aerial structures. The Contractor shall also submit construction equipment data for on-track construction equipment showing compliance with wheel contour, gauge, and clearance requirements.

3.02 ALIGNMENT DATA

A. Alignment information shown on the Contract Drawings refers to geometric control points for the track.

B. Engineering stationing is used to reference geometric control points. Independent stationing will be used for each track.

C. Mathematized alignment data for each track is included on the Contract Drawings.

3.03 TRACK GEOMETRY

A. Construct track to conform to the alignment and profile data as specified herein, and as indicated on the Contract Drawings.

B. For tangent track the alignment is based on each centerline of track, equidistant between the gauge sides of the running rails.

C. For curved track, the alignment is based on the centerline of track with the outside rail located 2 feet 4 1/4 inches radial from the centerline measured at the gauge line of the rails.

D. Measure track gauge as specified herein for Gauge, Track in Article 1.02, Definitions.

1. Tangent and curved track’s track gauge shall be 4 feet 8 1/2 inches.

2. Special trackwork’s track gauge shall be as indicated on the Shop Drawings of the VTA furnished Special Trackwork Materials.

3. Track Gauge shall vary on curved track as follows:

    a. Curve of radii great than or equal to 300 feet: 4 feet 8 1/2 inches

b. Curve of radii less than 300 feet: 4 feet 8 3/4 inches

4. Gauge narrowing or gauge widening. Make the change in track gauge at the rate of 1/8 inch in a transition length of not less than 15 feet. Begin gauge at spiraled curves beginning at the junction of the spiral and tangent, proceed toward the curve, and complete either before or at the junction of the spiral and the circular curve. Gauge at unspiraled curves shall occur on the tangents and shall be completed at the junction of the tangent and the circular curve. Gauge narrowing or widening shall be performed by moving the inside rail of the curve.

E. Flangeway Width

1. Flangeway width for restrained curves shall be 1 11/16 inches.

F. Rail Cant (Inclination)

2. Construct special trackwork with no rail cant.

3. Construct ballasted and direct fixation track with rail cant at 40 to 1 inward inclination of the rails.

G. Superelevation

1. Superelevated track curves as indicated on the Contract Drawings.

2. Track superelevation shall be accomplished by maintaining the inside rail of the curve at top of rail profile and raising the outside rail.

3. The superelevation at the tangent-to-spiral point shall be zero and shall increase uniformly through the length of the spiral to full elevation of the outer rail at the spiral to curve point unless otherwise shown on the Contract Drawings. Provide this spiral and superelevation at the ends of simple curves and segments of compound curves as indicated. Attain the superelevation on curves without spirals over equal lengths on the tangent and curve and increase linearly throughout the rate of change length.

4. Turnouts and Crossovers shall not be superelevated.

5. Metal tags shall be installed to mark the beginning and ending points of superelevation and every 1/4-inch increment between the beginning and ending points of the superelevation transition. Bond tags to concrete with epoxy approximately 1 foot inside the outside rail to read in the direction of increasing stationing.

6. Track curve information shall be as indicated on the Contract Drawings. Shop pre curved rail shall be marked by the manufacturer for proper installation by the Contractor.

H. Track Surface

Track surface is the relationship of both rails opposite each other in profile and cross level. Track profile is the running surface along the top of the rails. Cross level is the difference in elevation between the top of heads of opposite rails measured at right angles to the track alignment. The ideal surface is a uniform profile consisting of straight gradients connected by vertical curves, with zero cross level on tangents and predetermined cross level on curves.

3.04 TRACK CONSTRUCTION TOLERANCES

A. General track installation tolerances, except at platform area, which shall conform to requirements specified in Article 3.04B, shall be as specified in Table 1 below.

TABLE 1
TRACK CONSTRUCTION TOLERANCES (4)

Type of Track	Gauge(3) Inches	Cross Level(2) Inches	Horizontal Alignment Deviation (1)(3)	Vertical Alignment Deviation (1)(3)
Ballast (Primary)	+1/8	+1/8	+1/4(2)	+1/4
Direct Fixation	+1/8	+1/8	+1/4(2)	+1/4 (1)(2)

NOTES:

(1) Designed alignment and the actual constructed track position.

(2) Deviation at top of rail to adjacent concrete shall be plus 1/4 inch minus 1/8 inch.

(3) Rate of change variations in gauge, horizontal alignment, vertical alignment, cross level and track surface shall be limited to 1/8 inch per 15 feet of track.

(4) To verify that constructed track is within these tolerances an "as built" survey by an authorized survey team will be required. See Article 3.11 "Final Track Inspection".

B. For station platform area:

TABLE 2
TRACK CONSTRUCTION TOLERANCES AT STATION PLATFORM (4)

Type of Track	Gauge(3) Inches	Cross Level(2) Inches	Horizontal Alignment Deviation (1)(3)	Vertical Alignment Deviation (1)(3)
Ballast (Primary)	+1/8	+1/8	+1/8(2)	+1/8
Direct Fixation	+1/8	+1/8	+1/8(2)	+1/8 (1)(2)

3.05 TYPES OF RAIL

A. Rail for use as running rail for ballasted tracks, direct fixation tracks, grade crossing panelized track, and in special trackwork shall be 115 RE tee rail in accordance with Section 34 11 15, Running Rail.

1. Running Rail shall be either standard carbon or high strength rail as indicated on the Contract Drawings.

2. Special Trackwork components, closure rails, stock rails, guard rails and ladder tracks will

have 115RE high strength rails.

B. Running rail and restraining rail in curves having a horizontal centerline radius less than 500 feet shall be precurved by supplier from T.S. to S.T. 115 RE running rail with vertical curve radius less than 1000 feet and girder rail with a vertical curve radius less than 1500 feet shall be precurved by the supplier from PVC to PVT.

1. Perform field adjustments of precurved rail to match design radius as required.

c. Such field adjustments shall be incidental to the track installation and will receive no separate payment.

d. Perform field adjustments in a manner that will prevent permanent kink, twist, overstress or otherwise damage the rail.

C. Install rail section and type of rail at each location as indicated on the Contract Drawings.

1. Design strings of high strength rail:

a. To conserve high strength rail by minimizing the generation of unusable short rails;

b. To minimize the number of welds.

2. The minimum 15-ft plug rail that will replace the 15-ft rail to be removed with insulated joint shall be of the same type as the existing rail or proposed rail depending on its location. Locate weld joints in accordance with Article 3.06C.

3.06 RUNNING RAIL AND GUARD RAIL REQUIREMENTS

A. Running rail procurement is described in Section 34 11 15, Running Rails. Guard rail assembly components are described in VTA Standard Details Sheet STW-003.

B. Running rail for use in CWR track shall be welded in accordance with Section 34 11 44, Thermite Rail Welding.

1. Ends of CWR strings fabricated with a single hole, torch cut or drilled, to facilitate handling shall have such holes cut off with rail saw or abrasive cutting disc at least 3 inches from the hole prior to welding to another rail.

2. Handling and transporting CWR shall conform to the requirements of AREMA Chapter 5. Bumping and striking the rail during handling or laying shall not be permitted. Use rollers to facilitate transporting and avoid damage to rail, track appurtenances, and facilities.

C. Locate field welds so that they do not occur at the following locations:

1. Within 12 feet of another thermite field weld in the opposite rail.

2. Within 15 feet of a field weld in the same rail

3. Within 200 feet from the center of bolted joint.

4. On ballasted track within 200 feet of an aerial structure abutment.

5. Within 20 feet of a change of track construction other than that described above.

D. In butting CWR strings, where cutting is required to fit and where the option of cutting standard carbon or premium CWR exists, cut the standard carbon CWR string.

E. Cutting, drilling and beveling of rail for installation of bonded insulated joints:

1. Cut rails square and clean by means of either rail saws or abrasive cutting disks.

2. Do not cut rail for the installation of a bonded joint within 10 feet of an electric weld.

3. Accurately space holes for bolting of rail and drill with a rail drill in accordance with the requirements of AREMA Manual for Railway Engineering, Specifications for Rail Drillings, Bar Punchings and Track Bolts.

a. Drill cylindrical holes of specified diameter for the size bolt required through and perpendicular to the web of the rail.

b. Use a template as a drilling guide. In no case shall a joint bar be used for this purpose.

4. Remove rough edges from the bolt holes.

5. Rail ends in bonded joints shall be in accordance with the joint manufacturer's written specifications.

6. At bonded joints, end-harden standard carbon rail ends in the field that are not end hardened at the mill.

a. Remove joint bars and associated insulating materials from rail ends during the end hardening process.

F. Rail End Hardening

1. Submit the end hardening procedure and a list of trained or otherwise qualified personnel who will perform the end hardening on the rail in the field to VTA Representative.

2. Tests shall be performed by the Contractor in the field to determine rail end hardness and to assess hardness procedures, and results shall be sent to VTA Representative.

3. Standard rail and premium rail with Brinell hardness below 341 shall require end hardening.

G. Rail End Hardening Submittal and Tests

1. Two sample rails shall be end-hardened in accordance with the submitted procedure and tested by an approved independent laboratory. This applies to 115RE, Ri-59N, and Ri-52N girder rail.

a. Perform testing at no additional expense to VTA.

b. Acceptance of the end hardening procedure and personnel will be subject to the results of specified tests and samples. Acceptance will not be made if such results do not meet specified requirements.

H. End Hardening Tests

1. Test the two samples of end hardened rail for Brinell hardness in accordance with ASTM E10 using a standard ball (10 mm) and loading (3000 kgf) in longitudinal indentation increments at least two and one half times the diameters of the indentation on the rail head for a distance of six inches starting from the hardened end of the rail.

2. Record the hardness number and location.

3. The Brinell hardness number (BHN) shall not be less than 341 nor more than 401 when measured at a point on the centerline of rail 1/2 inch from the rail end.

   a. Decrease the hardness uniformly from the end of the rail to the hardness of the untreated rail in a distance of not less than 2 inches.

   b. The hardness pattern shall be uniform across the top surface of the rail head.

3.07 LAYING CONTINUOUS WELDED RAIL (BALLASTED TRACKS)

A. Laying, clamping, and fastening CWR shall be according to the following procedure.

B. Place the CWR on tie plates or concrete ties rail seat in accordance with the approved working drawings submitted in accordance with Section 34 11 44, Thermite Rail Welding.

C. Rail Temperature

Rail shall be installed to produce zero thermal stress in rail at 84°F, + 37°F or - 43°F. Opposite rails shall be installed with zero thermal stress temperatures within 37°F of each other. No final field welding of rail in its installed position shall be performed when rail temperature is not within these tolerances. Rail strings may be welded outside of track bed or rail trough without regard for thermal stress adjustment. Thermal stress adjustment shall be made upon installation of rail in its final position in the rail trough in accordance with method and procedure approved by VTA.

D. Final rail fastening with zero thermal rail stress in ballasted track shall not proceed until the track installation meets all the requirements specified on Section 34 11 26, Ballasted Track Construction.

3.08 JOINTS – WELDED, BONDED AND INSULATED

A. In primary track, use portable electric flash butt weld or thermite weld joints to connect CWR strings together and to join rails in special trackwork in accordance with Section 34 11 44, Thermite Rail Welding.

B. Bonded insulated joints shall be as specified in Section 34 11 93, Miscellaneous Trackwork Elements.

C. Locate bonded insulated joints as indicated on the Contract Drawings.

D. Install welds and bonded insulated joints in accordance with the manufacturer's recommendations and procedures.

E. Joints, including insulated joints, shall not be located opposite each other. Joints shall be staggered at least 2 feet 0 inches, but not more than 2 feet 6 inches from the joint on the opposite rail, unless otherwise noted on the Contract Drawings or approved by the VTA.

F. Existing insulated joints to be removed shall be replaced by minimum 15ft length plug rail. Adjust the length of the plug rail to meet the requirements of Article 3.05C.

3.09 SPECIAL TRACKWORK

A. Manufacturer's printed installation shop drawings and instructions for special trackwork assembly shall be furnished to the Contractor in accordance with Section 34 11 23.

3.10 RAIL GRINDING

A. Upon completion of the track installation to the specified tolerances, but prior to its final acceptance, grind running rail, except special trackwork items such as frogs and switch points, to the contour of the rail head with a rail mounted grinder.

B. Grind the top and gauge side corner of the running rail head. Remove rust, mill scale, and surface irregularities with successive passes of the rail grinder. The grinding wheel shall be not less than 10 inches in diameter and shall have controlled downward pressure to permit grinding more metal per pass at high spots and bridging at low spots less than 10 inches in length. Submit the type of equipment and method of operation to VTA Representative for acceptance prior to initiation of rail grinding.

3.11 FINAL TRACK INSPECTION

A. To determine the acceptability of the installation, the Contractor shall make a survey of the track and submit a copy to VTA Representative for review. Deviations from the Contract Drawings that exceed tolerances specified shall be corrected by the Contractor at no additional cost to VTA.

B. Upon completion of the Work required for final acceptance by VTA, Contractor shall request of VTA inspection of Work in writing. Within 10 working days from the date of receipt of the notification, VTA will inspect the work and furnish Contractor either by a letter confirming the completion of the Work in accordance with the Contract requirements or a letter outlining the deficiencies which require further work by Contractor. The follow-up inspection will be performed in the same manner as specified herein. Contractor shall correct deficiencies within time specified by VTA in order for a final completion of the Work to be considered.

C. A preliminary survey of the direct fixation and track surface and alignment shall be made by VTA before placement of concrete, grout or epoxy. Contractor shall allow sufficient time in the construction/work schedule for surveyors, Testing Agency and VTA construction inspectors to complete required tests and inspections. General Conditions GC-48 shall also apply, and potential claims of delay or additional costs will not be allowed for providing this access.

END OF SECTION 34 11 10

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SECTION 34 11 15

RUNNING RAILS

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for the design, manufacture, fabrications, inspection, testing, shipping, unloading, and stacking of standard running rail and premium running rails for the Project.

B. Related sections

1. 34 11 26 Ballasted Primary Track Construction.
2. 34 11 27 Direct Fixation Track Construction.
3. 34 11 43 Pressure Rail Welding.
4. 34 11 44 Thermite Rail Welding.

1.02 REFERENCED STANDARDS

A. Association of American Railroads (AAR): Current rules governing the loading of commodities on open top cars.

B. American Railway Engineering and Maintenance (AREMA)

1. Manual for Railway Engineering (AREMA Manual)
2. Portfolio of Trackwork Plans (AREMA Portfolio)

C. American Society for Testing and Material (ASTM):

1. A36M Standard Specification for Carbon Structural Steel.
2. A48M Standard Specification for Gray Iron Castings.
3. E10 Standard Test Method for Brinell Hardness of Metallic Materials.
4. E18 Standard Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials.
5. E428 Standard Practice for Fabrication and Control of Metal, other than Aluminum Reference Blocks Used in Ultrasonic Inspection.
6. E709 Standard Practice for Magnetic Particle Examination.

D. American Iron and Steel Institute (AISI)

1. Material 4340 Steel/Nickel Plate.

1.03 SUBMITTALS

A. The Contractor shall make all submittals in accordance with the requirements of Special Conditions SC-6 and SC-51 and as specified herein.

B. Submittals: The Contractor shall submit the following required items within 30 days of the Contract award date:

1. Description of the vacuum degassing process.
2. Description of the head hardening process and chemical composition of the rail.
3. Description of the non-destructive testing procedures.

C. Submittals in Performance of the Contract:

1. Submittal Date: The Contractor shall submit required items a and b to the VTA for approval at least 30 days before fabrication unless specified otherwise below. Fabrication shall not commence until these items are approved.
2. Required Items:
   a. Rail Certificate: Source, chemical composition, hydrogen reduction process, and heat treating process of the 115RE being supplied.
   b. Marking and Identification System: Description of the Contractor's system for marking and identifying sizes, types, and composition of products, as well as identifying parts for the purpose of proper location during installation.
   c. Shipping, Handling, and Stacking Procedures: A description of shipping, handling, and stacking procedures including a layout plan for storage yard in accordance with Article 1.04, herein, shall be submitted at least 30 days before shipping.
   d. Documents for Final Acceptance of Rail: The Contractor shall submit the following documents to the VTA for review at least 30 days before shipping. The Contractor shall not ship until the VTA approves them. Final acceptance of rail will be made only after VTA review and approval of these documents.
      1) Vacuum degassing and head hardening records.
      2) Non-destructive testing records.
      3) Mill certificates and results from rail hardness tests

1.04 HANDLING, SHIPPING, UNLOADING, AND STACKING

A. All rails shall be handled carefully to avoid damage and shall be loaded in rail cars or trucks with the branding on all rails facing the same directions, in accordance with the AREMA Manual, Volume 1, Chapter 4, Part 2, Section 2.1, "Specifications for Steel Rails," and the current rules governing the loading of commodities on open top cars published by the AAR.

B. Rails shall be delivered, unloaded, and stacked in accordance with a method approved by the VTA at the delivery sites indicated in Section 6, "Special Conditions," Subsection SC-7. The Contractor shall furnish all equipment, labor, rigging, dunnage, and other materials necessary to perform the work.

1. Bottom row of rails shall be placed on 7 inch by 9 inch minimum timbers spaced a maximum of 10 feet apart. Between rows, 2 inch by 4 inch minimum timbers shall be placed with a maximum distance of 10 feet between them.

C. Standard length and short length rails shall be stacked separately with all rail length markings to be exposed on one end of each stack.

D. The Contractor shall unload and stack rail to avoid damage to rail. Damaged rail shall be replaced promptly at the Contractor's sole expense.

1.05 MEASUREMENT AND PAYMENT

A. Full compensation for providing running rails shall be considered as included in the bid item for Ballasted Track Primary Construction and Direct Fixation Track Construction and no additional compensation will be allowed therefore.

PART 2 – PRODUCTS

2.01 PREMIUM STRENGTH RUNNING RAIL

A. All running rail shall be new 115RE sections, vacuum degassed carbon steel tee rail manufactured in accordance with the AREMA Manual, Volume 1, Chapter 4, Part 2, Section 2.1.4.1, "Specifications for Standard AREMA Chemistry Steel Rails", and as specified in VTA Light Rail Transit Standard Detail STW-002.

B. All premium/high strength running rail shall have a Brinell Hardness of 341 to 388 min.

C. Premium strength running shall be head hardened according to the manufacturer's standard head hardening process and in accordance with Paragraph 2.02A, Rail Hardening Treatment, herein.

D. Rail Branding and Stamping: Rail branding and stamping shall be in accordance with the AREMA Manual, Volume 1, Chapter 4, Part 2, Section 2.1, Article 2.1.6, "Specifications for Steel Rails, Branding and Stamping".

2.02 FABRICATION

A. Rail Hardening Treatment:

1. Rails for head hardening shall not include "A" rails or Number 2 rails. Rails to be treated shall be selected from heats of steel with a chemical composition capable of providing the required hardness when treated in the specified manner.

2. Head hardened rail shall be in accordance with the current AREMA Manual for high strength rail.

   a. The hardness of head hardened rail when tested in accordance with these technical specifications shall be within the range of 341 HB to 388 HB throughout the rail head.

Brinell Hardness determinations shall be made in accordance with ASTM E10, on a minimum of ten percent of the rails randomly selected in each quenching and tempering charge. Hardness tests shall be made on full rail sections from the same heat as the rails being treated. The test section shall be at least 10 inches in length. The hardness readings shall be taken at the midpoint of the hardness test specimens, with regard to both length and width, on the top of the rail head after removing the decarburized metal. If all the rails or samples tested meet the specified hardness, the rails represented will be accepted subject to the other requirements of these technical specifications. The results of the Brinell Hardness tests shall be furnished by the Contractor on the mill certification. The mill certificate shall contain the following data:

1) Identification of each rail in a charge by heat, ingot, and letter.

2) Identification of each equivalent sample by heat.

3) Listing of all Brinell readings.

4) A representative check of Brinell readings over the entire cross section.

5) Date of all phases of head hardened treatment for each charge. Indicate the acceptance or rejection of the rails in each charge.

b. If any rail or sample tested fails to meet the specified Brinell Hardness values, the Contractor shall perform additional hardness measurements, one on each side of the point first measured and each approximately 1 inch from that point. If both of these check measurements meet the required hardness, the rails represented will be accepted. If any of the rails or samples tested fail in the check test to meet the required hardness, each rail in the charge shall be tested and only those showing a hardness meeting these technical specifications will be accepted. Any rails failing to meet required hardness may be retreated, but not more than one additional time unless approved by the VTA. Rail, which has been retreated, shall be retested for hardness in accordance with these technical specifications.

c. After the final treatment, the rails shall be conditioned by straightening to comply with the current requirements of AREMA Manual, Volume 1, Chapter 4, Part 2, Section 2.1, "Specifications for Steel Rails"

B. Non-Destructive Test on Rail

1. The interior condition of the rails to be supplied to the VTA shall be determined by non-destructive testing. The Contractor's equipment, procedures, and standards shall be in accordance with the AREMA Manual, Volume 1, Chapter 4, Part 2, Section 2.1, Article 2.1.8, "Ultrasonic Testing".

2. The full length of each rail head, web, and base shall be ultrasonically tested by the Contractor for internal imperfections using the in-line ultrasonic testing equipment provided by the Contractor. The Contractor shall provide records of the cathode ray tube displays to the Engineer for any rail giving ultrasonic fault indications. The test block shall be Material 4340 AISI Steel/Nickel Plate conforming to ASTM E428.

3. Contractor shall conduct magnetic particle testing in accordance with ASTM E709 when it will provide a better indication of shallow defects and cracks. Magnetic particle testing will not be accepted as a substitute for the full ultrasonic testing.

C. Cutting, Drilling, and Beveling

1. Rails shall be cut square and clean by means of rail saws, shears, or abrasive cutting wheels only, in accordance with the current AREMA Manual, Volume 1, Chapter 4, Part 2, Section 2.1, “Specifications for Steel Rails”. Torch cutting is prohibited.

D. Markings

1. Each Premium high strength rail shall be marked with a 2 inch wide orange stripe painted on both sides of the web and around the rail head at a point approximately 3 feet from each end of the rail.

PART 3 – EXECUTION

3.01 EXAMINATION

A. The Engineer may examine any materials for defects, damage, or non-conformance prior to acceptance. The Contractor shall inspect and keep aware of the condition of the rail as it is being installed, and shall notify the Engineer of any suspected defects in any rail. Materials that are damaged or defective shall not be installed into the work, but shall be clearly marked by the Contractor and placed by the rail bed. Whichever means the contractor uses to mark defective rail, shall be communicated to Engineer and Contractor’s employees. Isolated defects shall be removed in accordance with this Section.

3.02 HANDLING AND INSTALLATION

A. Rail shall be installed in accordance with the requirements of Related Section 34 11 10, Track Installation – General Requirements, Related Section 34 11 26 Ballasted Track Primary Construction, and Related Section 34 11 27 Direct Fixation Track Construction.

B. Rail shall be handled by methods that will not result in damage to the rail. Rail shall not be dropped on uneven surfaces nor left unevenly supported. Rail handling shall conform to Section 1.04, “Handling, Shipping, Unloading, and Stacking”.

C. Running rail for construction shall be fabricated into continuous welded rail (CWR) strings of at least 1150 ft in length and up to 1320 ft in length using the electric flash-butt pressure rail welding process as specified in Section 34 11 43, “Pressure Rail Welding.” CWR strings shall be moved on rollers, and not dragged along the ground or across crossties

3.03 CUTTING AND DRILLING OF RAIL

A. The Contractor shall use only the following tools for cutting rail:

1. Rail Saw.

2. Abrasive Cutting Wheel.

B. Other methods for cutting rail shall not be acceptable. Cuts shall be square and clean. When given the option of cutting existing rail, or cutting the rail being installed, the existing rail shall be cut.

C. When new holes are necessary, they shall be drilled and not punched, slotted, or burned with a torch. A proper template shall be used. Each hole location shall be carefully center-marked and center-punched. Holes shall be of the size and location shown on the Plans. Drilled bolt holes shall be peened or ground to remove sharp edges. Tolerance for the diameter of drilled bolt holes is - 0, 1/15 inch.

D. A single handling hole may be drilled in the ends of CWR. The ends of rails with such a bolt hole shall be cropped a minimum of 3 inch from the bolt hole prior to joining with another rail.

3.04 QUALITY CONTROL AND ASSURANCE

A. The Contractor shall be alert to the presence of any defects in rail being installed.

B. The Engineer may make checks of rail wear or defects at any time during the Contract. Rail that is found to be defective shall not be installed in track, but shall be set apart from other new rail and marked with marking paint as defective.

3.05 DEFECTIVE RAIL

A. In tangent track, installed rail that has been found to be defective during construction shall be removed and replaced with 15 ft minimum length of defect-free rail. For rail in curves, the minimum length of replaced rail shall be 30 ft of defect-free rail. The defect-free rail shall be welded into the rail by the Contractor in accordance with Related Section 34 11 44, Thermite Rail Welding.

END OF SECTION 34 11 15

SECTION 34 11 23

SPECIAL TRACKWORK

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for the design, manufacture, fabrication, preassembly, inspection, testing, shipping, unloading, and stockpiling of special trackwork materials for the Project.

B. Special Trackwork to be furnished as part of this Contract include, but are not limited to the following items:

1. Complete ballasted No. 8 Double Crossover with timber ties, 29’-1” track center.
2. Complete ballasted No. 8 RH turnout with timber ties.
3. Complete ballasted No. 8 LH turnout with timber ties.
4. Complete ballasted No. 4 LH turnout with timber ties.
5. Spare parts for special trackwork.

C. Related Sections:

1. 34 11 28 Special Trackwork Construction
2. 34 11 34 Timber Switch Ties.

1.02 REFERENCED STANDARDS

A. Association of American Railroads (AAR):

1. Signal Manual.

B. American Railway Engineering and Maintenance-of-Way Association (AREMA):

1. Manual for Railway Engineering (AREMA Manual).
2. Portfolio of Trackwork Plans (AREMA Portfolio).

C. American National Standards Institute (ANSI):

1. B18.21.1 Lock Washers (Inch Series).
2. B18.22.1 Plain Washers.

D. American Society for Testing and Materials (ASTM):

1. A36/A36M Standard Specification for Carbon Structural steel.

2. A48 Standard Specification for Gray Iron Castings.

3. B633 Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel.

4. D257 Standard Test Methods for DC Resistance or Conductance of Insulating Materials.

5. E10 Standard Test Method for Brinell Hardness of Metallic Materials.

6. E428 Standard Practice for Fabrication and Control of Metal, other than Aluminum Reference Blocks Used in Ultrasonic Inspection.

7. E709 Standard Guide for Magnetic Particle Examination.

E. Santa Clara Valley Transportation Authority (VTA)

1. Light Rail Transit Design Criteria Reference Manual (VTA Design Manual).

1.03 DEFINITIONS

A. Special Trackwork: A generic term referring to turnouts, crossovers, track crossings, derails, and similar track items.

B. Ballasted Track: Track constructed of rails, ballast, and cross ties.

C. HB: Brinell Hardness Number as defined by ASTM E10.

D. LRV: Light Rail Vehicle.

E. WCLB: West Coast Lumber Inspection Bureau, same as WCLIB.

1.04 DESIGN CRITERIA

A. Light Rail Vehicle Characteristics and Operating Requirements: As specified in the VTA Design Manual, Figures 3.5.1.1, 3.5.1.2a, and 3.5.1.3.

B. Turnouts shall be curved split switch, insulated design.

C. Turnout and crossover layout in contract drawing is for reference only. The turnouts and crossovers shall be designed by the Contractor to conform to the alignment data provided on the contract drawing.

D. The design of all special trackwork components shall be submitted for approval as specified in Article 1.05, "Submittals," herein.

E. Ballasted Turnout Tie Criteria:

1. The tie layout in contract drawing is furnished for general guidance only. VTA will review tie layout submittals and may revise spacing to accommodate rail bonding and rail

joint locations.

2. Dimension of timber ties to be 7 in. deep x 9 in. wide and 9 ft. to 22 ft. long. Switch machine ties will be 15 ft. long to suit switch machine or switch stand installation.

3. Turnout tie spacing shall be in conformance with the contract drawings, as appropriate, ranging in dimensions from 19-1/4 in. to 24 in.

4. Switch tie spacing shall range from 19-1/2 in. to 22 in. at the switch machine head block ties. Tie cribs containing switch rods shall be 20 in. minimum spacing. The heel of switch shall be positioned in the middle of the tie crib with a tolerance of +/- 1 in.

5. Frog ties shall be 19-1/2 in. spacing with the main spacing tie positioned 4 in. behind (toward heel of frog) the 1/2 in. point of frog. Frog designs with integral bases will dictate positions of frog ties and are subject to shop drawing review for approval.

6. Turnout closure rail area between heel of switch and toe of frog shall include wider tie spacing not to exceed 24 in. Closure rail insulated joints shall be suspended installation (non-supported joint) and tie spacing shall be positioned to provide this arrangement with joints staggered apart in adjacent tie cribs, 5 ft. maximum to 2 ft. minimum.

7. Timber switch ties, in addition to the requirements listed herein, shall conform to Section 34 11 34, “Timber Ties.”

F. Ballasted Crossover Special Trackwork Tie Layout Criteria

1. Double crossover contains four (4) turnouts and one (1) diamond crossing.

2. The turnouts in the double crossover will have the same geometry as the ballasted turnouts. Turnout ties shall have similar spacing requirements as ballasted turnout ties listed in Section 1.04 E.

3. The tie layout in contract drawing is furnished for general guidance only. VTA will review tie layout submittals and may revise spacing to accommodate rail bonding and rail joint locations.

1.05 SUBMITTALS

A. The Contractor shall make all submittals in accordance with the requirements of Special Conditions SC-6 and SC-51 and as specified herein.

B. The Contractor shall submit the following required items within 10 days of the contract award date:

1. A Product List consisting of a listing by product type, name of supplier, and model number of all proposed Contractor and subcontractor supplied products. Product literature or catalog cuts, material composition, and method of manufacturing shall also be included.

2. Description of the vacuum degassing process.

3. Description of the head hardening process and chemical composition of the rail.

4. Description of the non-destructive testing procedures.

5. Description of the procedures, equipment, and tolerances for precurving rail.

C. Submittals in Performance of the Contract:

1. Submittal Date: The Contractor shall submit the required items to VTA for approval at least 30 days before fabrication unless another submittal date is specified below. Fabrication shall not commence until the items requiring approval before fabrication are approved.

2. Required Items:

a. Shop Drawings:

1) Switch and Crossover Tie Layouts: Indicate the sizes and locations of ties in relation to the special trackwork units. See Article 1.04E., herein, for design criteria.

2) Special Trackwork: Design and submit a detailed layout of all components for the turnouts and crossovers to be supplied under this contract.

b. Flangeway Width and Gauge Calculations: Submit with the shop drawings, design calculations deriving the proper flangeway width through frogs, guard rails, restraining rails and switches, as well as gauge widening requirements through special trackwork.

c. Rail Certificate: Indicate source, chemical composition, hydrogen reduction process, and head hardening process of the 115RE rail to be supplied.

d. Rail Welding: Proposed welding and test procedures for special trackwork components that are to be welded.

e. Marking and Identification System: Description of the Contractor's system for marking and identifying sizes, types, and composition of products, as well as identifying parts for the purpose of proper location during installation, in accordance with Article 2.16, "Markings," herein. Rail joints, including bonded, insulated, and to joints to be field welded, within the limits of each special trackwork unit, shall be identified by sequential numbering.

f. Depth Hardening Procedure: Description of the proposed procedure for depth hardening of turnout and crossing frog castings, the area of each frog to be depth hardened, and the Brinell Hardness patterns which the Contractor normally achieves with such procedures.

g. Shipping and Handling Procedures: Description of packaging, shipping, handling, unloading, and stacking procedures, in accordance with Article 1.06, "Handling, Shipping, Unloading, and Stockpiling," herein. Provide layout of special trackwork material storage in the storage yard. Submit at least 30 days before scheduled shipping date.

h. Assembly Procedures: Submit assembly procedures, including placement plans, to be followed by the installation contractor 30 days before delivery of the supplied materials. The procedures shall be comprehensive, clear, and concise and shall include sequential layout and assembly steps to be followed by the construction contractor in building of each special trackwork unit in the field.

i. Operating and Maintenance Data Manuals:

1) Information contained in the operating and maintenance data manuals shall include the following:

a) The finish hardware schedule.

b) The description of and operation and maintenance instructions for special trackwork assemblies, including complete parts list.

c) The periodic maintenance schedule for all components of the special trackwork, including critical locations which will require lubrication; type of lubrication to be applied; components which will require adjustments or tightening; components which will require periodic inspection, and the frequency at which components requiring periodic inspection should be inspected.

d) Tools required and torque for all threaded components and fasteners.

e) Tolerances and wear limits for all adjustable components and components subject to wear.

f) Names, addresses, and telephone numbers of subcontractors and suppliers responsible for special trackwork assemblies.

2) The information contained in the operating and maintenance data manuals shall be arranged in an order that parallels the breakdown in these technical specifications. The technical specifications section titles shall be used to identify relevant data. Hard paper divider sheets marked with labeled vinyl-protected tabs shall separate the data.

j. Copies of Brinell Hardness test results for all non-rail items with specified hardness, 10 days prior to VTA Final Acceptance date.

k. Documents for Final Acceptance of Rail:

1) VTA's Review: Final acceptance of the rail will be made only after VTA's review and approval of the documents required below. Submit these documents to VTA for review at least 30 days before shipping and do not ship until VTA approves them.

2) Required Documents:

a) Vacuum degassing and head hardening records.

b) Non-destructive testing records.

c) Mill certificates and results from rail hardness tests.

d) Certificates of compliance from original steel manufacturer.

l. Six complete samples of lag screw assembly including lag screw, insulating bushing, (one of each length), double coil spring and flat washer shall be provided as a sample during the submittal process for each item. Once approved by VTA, materials and dimensions for each item of lag screw assembly may not be changed without prior written approval of VTA.

m. Submit the following required items to VTA for approval 25 calendar days after the Notice to Proceed unless another submittal date is specified below:

1) Submit a schedule of machining, treatment and delivery of timber ties.

2) Submit list of preservatives for approval.

3) Submit completed treatment records form specified in AREMA Manual, Chapter 30, Part 6, Section 6.4, Preservatives, 7 calendar days prior to shipment of ties.

4) Submit certificates of compliance for preservative treatment, ascertaining conformance with the approved preservative within 7 calendar days after completion of testing.

5) Submit Inspection Certificate from the WCLB for grading compliance 25 working days prior to application of preservative treatment.

6) Submit test results and certificates of compliance for preservatives used in treatment of switch ties no later than 25 working days prior to treatment.

3. Electronic Medium: Shop drawings shall be prepared in AutoCAD Release 2016 or later and in Acrobat format. Final shop drawing files (after approval by VTA) shall be downloaded onto CD and furnished to VTA prior to release of payment to Contractor.

1.06 HANDLING, SHIPPING UNLOADING, AND STOCKPILING

A. Metal Preservative Coating: All machined surfaces and threaded components shall be coated with a light petroleum based (non water soluble) lubricant. Any component shipped across the ocean shall be enclosed in a watertight container.

B. Packaging:

1. All turnouts and crossovers shall be packaged separately as complete units in secured bundles. Each unit shall be designated by a number to be provided by VTA.

2. The Contractor shall propose a packaging method for review and acceptance by VTA. The proposed method shall limit the amount of "bundles" for each unit to the absolute minimum possible and shall indicate how the materials will be stacked and marked to allow for easy identification of all the components that are part of the same unit.

3. Trackwork timber ties shall be handled, shipped, and stored in accordance with the AREMA Manual, Chapter 30, Part 5. To minimize damage to ties, they shall not be handled unnecessarily. Only lifting devices that will not cause damage to the tie shall be

used.

C. Marking: All bundles, boxes, and kegs specified in Article 1.06B., herein, shall be clearly marked with the following: Identification of item contained; Contractor's name; Contract No.; shipping date; number of pieces; gross weight; trackwork unit designation including left or right hand; customer's name and delivery address to be provided by VTA.

D. Shipping, Handling, Unloading and Stockpiling: Special trackwork procurement materials shall be unloaded and stockpiled using a method approved by VTA. The unloading and stockpiling site will be accessible by truck.

1. The Contractor shall furnish all equipment, labor, rigging, dunnage, and other materials necessary to perform the work.

2. Any item lost or damaged during shipping, unloading, and stacking shall be promptly replaced at the Contractor's sole expense.

3. The shipping inventory list sent prior to shipment shall be presented in the same format as the shipment inventory list for ease of checking.

4. Special trackwork units shall be stacked separately to allow individual removal by the installation contractor.

E. Delivery: The exact location of the delivery sites will be provided to the Contractor within 4 weeks after NTP. Delivery sites will be within 20 mi. of the project installation site.

1.07 MEASUREMENT AND PAYMENT

A. Measurement: Special trackwork turnout and crossover shall be measured by each unit.

B. Payment: The contract price paid per each turnout and crossover shall include full compensation for furnishing the special trackwork turnouts and crossovers and shall include all items required for a complete installation.

C. Spare Parts for Special track Work shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices and no additional compensation will be allowed therefore.

PART 2 – PRODUCTS

2.01 RAIL

A. Tee rail for special trackwork components, including switch rails, stock rails, closure rails, wing rails and straight and precurved running rails and guard rails shall be vacuum degassed and head hardened manufactured in accordance with the current AREMA Manual, Specifications for Steel Rails, and as specified herein. The rail shall be new 115RE sections conforming to the applicable special trackwork unit.

B. Head hardened rail shall be treated according to the manufacturer's standard process and in accordance with Article 2.14, "Rail Hardening Treatment," herein.

C. All tee rail shall have a Brinell Hardness within the range 341 HB to 388 HB.

2.02 STOCK RAILS

A. Stock rails for turnouts shall be fabricated from head hardened rail as defined in Article 2.01, "Rail," herein. Stock rails for turnouts shall be undercut in accordance with the AREMA Portfolio Plan No. 221, Detail 5100.

B. Stock rail ends shall be left blank to allow field welding by others. See Article 2.17, "Cutting, Drilling and Beveling," herein, for information on rail ends for.

2.03 CLOSURE RAILS

A. Closure rails for turnouts shall be fabricated from head hardened rail as defined in Article 2.01, "Rail," herein. Closure rails shall be fabricated to the correct length as required for the installation of thermite welds with 1 in. gap. Closure rails of radius less than 400 ft. shall be precurved by conventional railroad industry frog and switch shop procedures.

B. Except at insulated joint locations, closure rail ends shall be left blank to allow field welding by others. See Article 2.17, "Cutting, Drilling, and Beveling," herein, for information on rail ends for various types of special trackwork components.

C. Curved closure rails on insulated turnouts shall be furnished with insulated joint as specified in Article 2.12, "Bonded Insulated Joints," herein. The 36 in., 6-hole bonded insulated joint shall be supplied as a kit to be installed by others.

2.04 SWITCHES

A. General: Switches shall be curved split switch design with manganese steel tips, fabricated in accordance with the AREMA Portfolio Plan No. 100, Specifications for Special Trackwork, as modified in these technical specifications. Alignment and assembly tolerances shall be in accordance with the AREMA Portfolio Plan No. 1011. Switch points shall be fabricated for installation with undercut stock rails.

B. Switch rails shall be fabricated from tee rail conforming to the requirements of Article 2.01, "Rail," herein.

1. Switch rails for turnouts shall use double reinforced 115RE head hardened rail per AREMA Manual. Huck bolts shall be used to secure the reinforcing bars to the switch rail. Rivets shall not be used.

2. Switch rail lengths for turnouts shall be as indicated on contract drawings.

3. Switch points shall be in accordance with the AREMA Portfolio Plan No. 221, Detail 5100.

C. Switch Rod Assemblies:

1. Switch rods and clips shall be vertical design, such as Racor type SMJ as manufactured by the ABC Rail Corporation, or VTA-approved equal. Steel switch rods shall conform to the AREMA Portfolio Plan No. 100, "Specifications for Special Trackwork." Switch rod ends for manual switch machine locations shall be as shown on Figure 4.

2. For turnouts, switch rods and clips shall be insulated. Insulated switch rod assemblies

shall conform to the AAR Signal Manual Part 116, Signal Specification, Assembly and Test of Insulated Track Fittings. The Contractor shall certify conformance with the dielectric requirements of that Specification.

3. Fiber Insulation for Switch Rod Assemblies:

   a. Fiber angles, plates and end posts shall be fabricated of fiberglass mat reinforced polyester 3/16 in. thick, GPO-1 Sheet Stock NEMA, Class B.

   b. Fiber bushings shall be fabricated of NEMA Grade 10 epoxy glass fabric.

   c. All cut edges of fiberglass shall be sealed with Sherwin Williams Polane, 2-part coatings, or VTA-approved equal.

   d. All contact metal surfaces shall be painted with General Electric insulating enamel, Red Glyptol No. 1201, or VTA-approved equal.

   e. During assembly, a bead of silicon rubber paste, Devon Silite 100, General Electric RTV.102, or VTA-approved equal, shall be placed at the seat of angle bends between gauge plate, insulation, and steel angles.

   f. During assembly, all void areas between the outside edge of bolts and the inside edge of holes in angles shall be filled with clear silicon rubber paste, Devon Silite 100, General Electric RTV.108, or VTA-approved equal.

   g. As an alternate, 3/4 in. x 8 in. x 9 in. scotch ply insulation may be proposed.

4. Power operated switches shall have insulated switch rod No. 1 and shall be provided with basket adjustments and shall be 2-1/2 in. x 1-1/4 in. with bolt hole diameter of 1-9/64 in.

D. Heel Block Assembly:

1. Split switches for welded turnouts shall be furnished with a floating heel assembly, as designed by the Contractor. The design shall be subject to review and approval of VTA.

2.05 RAIL BRACES

A. Adjustable rail braces shall be provided for all switches in accordance with Bethlehem Steel Corporation Sure Fit Boltless Adjustable Brace or VTA-approved equal and AREMA fit requirements for Type A braces as shown on AREMA Portfolio Plan No. 224

B. The adjustable brace shall have a locking device to prevent loosening of the rail brace wedge and shall be designed to permit easy removal of the wedge using standard track tools.

2.06 FROGS

A. As part of the design of the turnouts and crossovers, the Contractor shall submit, for review and approval, a design for each of the turnout and crossover frog to be procured in this Contract. The following are the minimum requirements for the frogs.

B. Turnout frogs shall be tread bearing railbound manganese and diamond crossing frogs shall be flange bearing solid manganese steel frogs. Both types shall meet the requirements of these technical specifications. All manganese frog castings shall be high integrity castings with minimum Brinell hardness of 352.

1. Railbound manganese frogs shall conform to the AREMA Portfolio, Specification 100-92 and Plans 600A-79, 600B-79 and 621-89. The impact areas and running surfaces of frogs shall be depth hardened in accordance with M2.7, Depth Hardening, of AREMA Portfolio Plan 100-89; however, M2.7.5 will not be acceptable.

2. Diamond crossing flange bearing solid manganese steel frogs shall conform to the AREMA Portfolio, Specification 100-92 and Plans 772-80 and 773-80. The frogs are to be milled to provide compatible head profiles in accordance with the AREMA Portfolio and the wheel profile shown on VTA Light Rail Transit Design Criteria Manual, Figure 3.5.1.3. The impact areas of frogs shall be depth hardened in order to provide the Brinell Hardness requirements of M2.7, Depth Hardening, of AREMA Portfolio Plan 100-92. Flange bearing slope shall be 1 to 16 with a 1/16 in. tread to frog clearance.

C. All frogs shall be designed to accommodate the wheel flange of the light rail vehicle. The points shall be depressed in accordance with AREMA Portfolio Plan 600B. Alignment and assembly tolerances shall be in accordance with the AREMA Portfolio Plan 1010.

D. Turnout frog lengths shall be as indicated on contract drawings.

E. Frogs shall be furnished with all necessary tie plates as indicated in Article 2.08, "Plates," herein.

F. All impact and wear areas shall be ground smooth to a finished surface.

2.07 GUARD RAILS

A. Guard rails for use with turnout frogs shall be fabricated from planed tee rail in accordance with the AREMA Portfolio Plan No. 504. Guard rails shall be flush with the plane of running rail. They shall conform to the AREMA Portfolio Plan No. 100, Specifications for Special Trackwork, M3, Carbon Steel Castings; or M4, Gray Iron Castings, ASTM A 48, Class 50; or M5, Malleable and Ductile Iron Castings. Rail shall be as specified in Article 2.01, "Rail," herein.

2.08 PLATES

A. Plates to be provided in this Contract include all the required plates and rail stops within the limits of special trackwork. Insulated gauge plates shall be provided at the switch and frog area as shown on the Contract drawings. Plates shall conform to the AREMA Portfolio Plan No. 100, Specifications for Special Trackwork, Section M7, "Rolled Mild Steel." Standard plate thickness shall be 3/4 in. Insulated gauge plates at the switch shall be designed using uniform risers similar to AREMA Plan 123. Holes shall be clean and deburred top and bottom.

B. Switch and frog gauge plates for turnouts and crossovers shall be insulated in accordance with the AREMA Portfolio Plan No. 223. Insulation materials shall conform to the requirements of Subparagraph 2.04.C.3, Fiber Insulation for Switch Rod Assemblies, herein. Switch gauge plates for power operated switches shall have field end of plate bent up in accordance with AREMA Portfolio Plan No. 223.

C. All rails shall be secured to plates with threadless spring clip fastenings. Plates for ballasted special trackwork will be secured to switch ties with lag screw assemblies.

2.09 LAG SCREW ASSEMBLY

A. Each lag screw assembly includes a double coil spring washer, flat washer, and an insulating bushing. A minimum of 4 lag screws shall be used for each plate. Insulating tie pads shall be provided for all plates. There shall be a minimum of 1/2 in. of clearance between tie pads of adjacent plates at the heel of switch and the toe and heel of frogs.

1. Lag screws shall be 3/4 in. diameter at the shank, 7 in. in length, twin lead threads, heat treated medium carbon steel with a tensile strength of 150 000 psi. Lag screws shall have a 3/4 in. square head and shall provide 2 in. smooth shank under the head and 5-1/8 in. of thread originating from a sharp, self-tapping point. Screw threads shall be 5 per 1 in. All screws furnished for all components supplied under this Contract shall be identical.

2. Insulating bushing shall be a 1-piece, toughened, impact modified, glass reinforced, heat stabilized nylon resin, meeting the following requirements:

   a. Tensile Strength at 73ºF: 6000 psi minimum.

   b. Elongation at Break at 73ºF: 210 +/- 10 percent.

   c. Flexural Modulus at 73ºF: 125 000 psi minimum.

   d. IZOD Impact at 73ºF: 20 ft-lb./in. minimum.

   e. Electrical Resistivity for 50 percent RH, 2 in. disc and 0.1-inch thickness, in accordance with ASTM D257: 4000 x 10^{10} volume ohm-in.

   f. Insulating bushing shall be color coded to distinguish between various lengths.

3. Insulating tie pad material shall be high density polyethylene, having the following characteristics:

   a. Tensile Strength: 3500 psi minimum.

   b. IZOD Impact: 0.6 ft-lb./in. 1/2 in. bar.

   c. Rockwell Hardness: Shore D: R60 minimum.

   d. Specific Gravity: 0.95 minimum.

   e. Thermal Expansion Coefficient: 55 x 10^{-6} mm/(mm. ºF) (in./in. ºF).

   f. 24-Hour Water Absorption: Less than 0.03 percent.

   g. Electrical Resistivity for 50 percent RH, 2 in. disc and 0.1-inch thickness, in accordance with ASTM D257: 4000 x 10^{10} volume ohms-in.

   h. Insulating tie pads shall be 3/8 in. thick, provide full support under all turnout plates (including switch and frog gauge plates) and shall extend 1/2 in. beyond all edges of each plate.

   i. Insulating tie pads shall be drilled with 7/8 in. holes to match the hole pattern of the appropriate tie plate.

j. Insulating tie pads for gauge or other long plates may be furnished in two end-to-end fit pieces. However, each and any tie pad must be retained in its position by a minimum of 4 lag screw assemblies.

k. Insulating tie pads shall be black in color and shall be designed to resist degradation by exposure to sunlight (UV-resistant).

4. Washers, spring and flat, diameter as required, carbon steel, zinc electro-deposited in accordance with ASTM B633, Type II, SC4.

a. Flat washers shall be ANSI B18.22.1, Type B, Regular. Outside diameter as required.

b. Spring washers shall be ANSI B18.21.1, double coil helical spring, extra duty.

B. Lag screw assemblies, insulating tie pads and insulating bushings are required on all special trackwork plate work including gauge plates and switch plates.

C. The bottom of plate shall be parallel to the rail seat so as to provide no cant to the rail, and shall be flat and without any downward projections.

2.10 ANCHOR BOLT ASSEMBLY

A. Each anchor bolt assembly includes anchor bolt, nut, rebound spring, washers, insulating bushing and epoxy grout. A minimum of 4 anchor bolts shall be used for each plate, two on each end of the plate.

B. Contractor shall provide certification from the epoxy grouted anchor bolt system supplier that the functional strength of a properly installed device exceeds 11,000 lbf of pull-out force and shear force when tested in accordance with ASTM E 754 and C900.

C. Contractor shall provide certification that anchor bolt component meets the following minimum requirements:

1.	Anchor bolt	ASTM A 36
2.	Anchor nut	ASTM A 563, Grade A
3.	Washer	ANSI B.18.22.1 Type A Plain
4.	Spring	Shall be double helical steel with loading and unloading points at a nominal 4,500 lbf at 5/32 in. depressed.
5.	Insulating busing	ASTM D 638 – Tensile strength at 73º F – minimum 14505 psi, Elongation at break at 73º F – Minimum 3%. ASTM D 257 – Volume resistivity 40 x 10^7 ohms-in. ASTM D 570 – Water absorption 24 hours @ 73º F – Maximum 0.6%.
6.	Epoxy grout	Vinyl Ester Resin with a Dibenzoyl peroxide Hardener or equivalent.

D. Each anchor bolt assembly shall be supplied with all nuts and washers necessary for proper installation.

E. The epoxy grout shall be packaged in containers that provide the appropriate proportion of each component.

F. Anchor bolts shall be 7/8 inches diameter and extend into the base slab a minimum of 6-1/2 inches.

G. Anchor bolt, nut, washers and spring shall be plated to ASTM B 633 SC1.

H. The epoxy grouted anchor bolt system will be subject to approval by VTA

2.11 CASTINGS

A. Castings shall conform to the appropriate Section of the AREMA Portfolio Plan No. 100, Specifications for Special Trackwork, Sections M2 through M5. The material for each casting shall be shown on the shop drawings. Radiographic testing is required at locations in compliance with AREMA Criteria 1 and 2. Sectioning is not required.

B. All Manganese castings shall be radio graphically tested.

2.12 BONDED INSULATED JOINTS

A. Bonded insulated rail joints shall be furnished with welded insulated turnouts and insulated double crossovers. Location and number of insulated joints required for turnout and crossover are as indicated on the contract drawings. Contractor may adjust locations to allow placement between ties as long as all other requirements of the Specifications are met. Bonded insulated joints shall be 36 in.), 6-hole full contact bars conforming to the appropriate rail section. Bonded insulated rail joints falling within the limits of guard rail or extended guard rails shall be fabricated with insulated joint to include running rail and guard rail.

1. Bonded insulated rail joints shall be factory fabricated within closure or other rails as indicated on the Figures. Contractor shall devise a rail and switch tie layout such that the center of the insulated joint will be situated between plates. Insulated joints shall be located no closer than 13 ft. from the end of the rail in which it is installed. Special insulated rail joints shall be factory fabricated for guard rail locations, as indicated on the Figures.

2. The number of bonded insulated joints required for each insulated special trackwork unit shall be as indicated below:

   a. Single turnouts: 2.

   b. Double crossover: 12.

3. Bars shall be of quenched carbon steel conforming to AREMA Manual Specifications for Quenched Carbon Steel Joint Bars. The inside face of the joint bars shall be preglued insulating material and shall be smooth with no stampings or branding.

4. Insulating materials shall be of high pressure, laminated design impervious to oil, grease and water and shall have electrical resistance characteristics meeting or exceeding the

requirements of the AAR Manual, Part 116, "Signal Section Specification."

5. End posts shall match the cross section of the rail and shall be 3/8 in. thick.

6. Bonded insulated joints shall be furnished complete with end posts, bushings, bolts, nuts, and washers. Bolts, nuts and washers shall be as specified in Article 2.11, "Bolts, Nuts and Spring Washers," herein.

7. Special modified rail joint spring clip fastenings shall be furnished with bonded insulated joints to secure rails to tie plates at the location of the joint. Four spring clips shall be provided with each joint.

2.13 BOLTS, NUTS AND SPRING WASHERS

A. Bolts, nuts and spring washers shall conform to the AREMA Portfolio Plan No. 100, Specification for Special Trackwork, Sections M11, "Bolts and Nuts," and M12, "Spring Washer." Tolerances shall be in accordance with the AREMA Portfolio Plan No. 100, Specifications for Special Trackwork, Article 7.1, "Fit of Bolts."

B. Furnish torque specification for each bolt application.

2.14 RAIL HARDENING TREATMENT

A. Rails for head hardening shall not include "A" rails or Number 2 rails. Rails to be treated shall be selected from heats of steel with a chemical composition capable of providing the required hardness when treated in the specified manner.

B. Head hardened rail shall be in accordance with the current AREMA Manual for high strength rail.

1. The hardness of head hardened rail when tested in accordance with these technical specifications shall be within the range of 341 HB to 388 HB throughout the rail head. Brinell Hardness determinations shall be made in accordance with ASTM E10, on a minimum of 10 percent of the rails randomly selected in each quenching and tempering charge. Hardness tests shall be made on full rail sections from the same heat as the rails being treated. The test section shall be at least 10 in. in length. The hardness readings shall be taken at the midpoint of the hardness test specimens, with regard to both length and width, on the top of the rail head after removing the decarburized metal. If all the rails or samples tested meet the specified hardness, the rails represented will be accepted subject to the other requirements of these technical specifications. The results of the Brinell Hardness tests shall be furnished by the Contractor on the mill certification. The mill certificate shall contain the following data:

   a. Identification of each rail in a charge by heat, ingot, and letter.

   b. Identification of each equivalent sample by heat.

   c. Listing of all Brinell readings.

   d. A representative check of Brinell readings over the entire cross section.

   e. Date of all phases of head hardened treatment for each charge. Indicate the acceptance or rejection of the rails in each charge.

2. If any rail or sample tested fails to meet the specified Brinell Hardness values, the contractor shall perform additional hardness measurements, one on each side of the point first measured and each approximately 1 in. from that point. If both of these check measurements meet the required hardness, the rails represented will be accepted. If any of the rails or samples tested fail in the check test to meet the required hardness, each rail in the charge shall be tested and only those showing a hardness meeting these technical specifications will be accepted. Any rails failing to meet required hardness may be retreated, but not more than one additional time unless approved by VTA. Rail, which has been retreated, shall be retested for hardness in accordance with these technical specifications.

3. After the final treatment, the rails shall be conditioned by straightening to comply with the current requirements of AREMA Manual, Specifications for Steel Rails.

2.15 NON-DESTRUCTIVE TEST ON RAIL

A. The interior condition of the rails to be supplied shall be determined by non-destructive testing. The test equipment, procedures, and standards shall be in accordance with the AREMA Manual, Volume 1, Chapter 4, Part 2, Section 2.1.8, "Ultrasonic Testing," and as modified in this Article.

B. The full length of each rail head, web, and base shall be ultrasonically tested for internal imperfections using in-line ultrasonic testing equipment provided by the Contractor. The Contractor shall provide records of the cathode ray tube displays for any rail giving ultrasonic fault indications. The test block shall be Material 4340 AISI Steel/Nickel Plate conforming to ASTM E428.

C. Magnetic particle inspection in accordance with ASTM E709 is acceptable as a complementary method when it provides a better indication of shallow defects and cracks, but it will not be accepted as a substitute for ultrasonic testing.

2.16 PRECURVING OF RAIL

A. Rails with track centerline radius of 300 ft. or less shall be precurved. Precurving of rail shall be accomplished by conventional railroad industry frog and switch shop procedures approved by VTA.

B. The bending radii and number of precurved closure rails required will be determined by the Contractor for each of the special trackwork components. The deviation from the theoretical middle ordinate in any 3 ft. chord shall not exceed +/- 1/16 in. The deviation from the theoretical middle ordinate of the 39 ft. rail section shall not exceed +/- 1/4 in. Rail base shall seat flat with no raised edge after precurving.

C. The Contractor shall calculate equivalent compound curve radii in order to precurve spirals throughout their length. Precurving of spirals using computer controlled roller curving equipment is acceptable.

D. Precurved rails that are entirely within the circular curve or spiral shall be curved throughout the entire length. Straight ends resulting from the precurving process shall be cropped prior to shipment. The cropped ends will not be included for measurement and payment.

E. Gag bending will not be acceptable.

2.17 GAUGE WIDENING

A. Track gauge and flangeway width shall be as specified in Section 34 11 10, Track Installation General Requirements.

2.18 CUTTING, DRILLING, AND BEVELING

A. Rails shall be cut square and clean by means of rail saws, shears or abrasive cutting wheels only, in accordance with current AREMA Manual, Specifications for Steel Rails. Torch cutting is prohibited.

B. Rail ends shall be left blank for welded turnouts.

C. 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 for fasteners through each plate perpendicular to its face, and shall be clean cut, leaving no torn or ragged edges. Drilled bolt holes shall be ground to remove sharp edges.

2.19 MARKINGS

A. Each head hardened rail shall be marked with a 2 in. wide orange stripe painted on both sides of the web and around the rail head at a point approximately 3 ft. from each end of the rail.

B. Each precurved closure rail shall be stencil marked with the turnout identification number, the precurve bend radius, and a designation of inside or outside rail. The marking shall be on the web 3 ft. from one end in letters and numerals not less than 3 in. high. The marking shall be legibly painted on a background of permanent black paint.

C. Markings identifying the installed location of each component of special trackwork shall be painted before shipment. Standard switches, frogs, stock rails, and closure rails shall be marked with a stock number. Such markings shall be placed on the side near the end of the piece with letters and numerals not less than 4 in. high. Markings shall not be in other (adjacent) components. Markings shall be stencil painted with white paint on a background of permanent black paint.

1. Stock and closure rails shall have switch length, right hand or left hand, and stock number on web at the end most remote from the location of point of switch.

2. Frog rail assemblies shall have stock number on web of rail on side opposite machining.

3. Guard rail assemblies shall have stock number on web of rail on side opposite machining.

4. The gauge plate assembly, switch plate assembly, and switch rod assembly shall have their stock numbers stenciled.

5. Marking of tie pads shall be in permanent paint at least 1 in. in height identical to the tie plate stamping to which it corresponds. Tie pad identification shall be between predrilled holes at one end of pad, oriented facing and parallel to the running rail.

D. Stamped and Painted Markings: The ends of each abutting section at a joint in each special trackwork layout shall be legibly with the joint number as shown on the approved shop drawings. Plate and switch rod assembly identification markings shall be clearly stamped with letters and figures not less than 1/2 in. in height, located on the top surface of the plates, plainly visible when assembled, and not subject to wear. Die stamping shall be done in figures not less than 5/8 in. high. Markings shall include rail section, left hand or right hand, switch length, and plate number.

E. Tags: Switch point rail identification shall be accomplished by attaching an aluminum tag to the gauge side of the rail. Tags shall identify switch length, rail section, curved or straight, right hand or left hand, and stock number.

F. Parts belonging to a particular turnout shall be color coded for ease of field installation. Color coding of parts shall be done after shop assembly.

2.20 INSPECTION

A. Before shipment, the turnouts and crossover as indicated in this contract shall be completely assembled in the Contractor's fabrication shop for inspection by Contractor. Closure rails shall be cut to the lengths required for installation. Assembly of trackwork for Contractor's inspection shall be at Contractor's expense. All costs associated with transportation, meals, boarding for Contractor's inspection team will be at Contractor's expense.

B. Contractor will make a maximum of 2 trips to inspect the assembled trackwork items. The Contractor shall notify VTA at least 4 weeks before the shop assembly inspection. It is expected that Contractor's representatives will spend a full 8-hour day at the shop during each inspection trip. Contractor shall provide safe access to the laydown area and assist with the inspection activities as required.

C. Joints shall be firmly clamped to secure components in place. No support blocking or gauge rods will be permitted to hold components to proper alignment throughout the unit during the inspection process.

D. Any variations from the tolerances, dimensions, lengths, or angles shown on the approved shop drawings shall be noted by the Contractor on the final shop drawings and tie and fastener layout drawings.

2.21 SPARE PARTS

A. General: Spare parts for all special trackwork components shall include necessary parts by identification number and quantity.

B. Items to be supplied as Spare Parts:

1. 1 left hand curved switch point with stock rail, blank ends for No. 8 turnout.
2. 1 right hand curved switch point with stock rail, blank ends for No. 8 turnout.
3. 1 left hand curved switch point with stock rail, blank ends for No. 4 turnout.
4. 1 frog for No. 8 turnout.
5. 1 frog for No. 4 turnout.
6. Two hundred each lag screw assemblies consisting of lag screw, insulating bushing for 3/4 inch plate thickness, double coil spring washer and flat washer.
7. Insulating tie pads, blank, without drilling:

    a. Fifty each, 9 inch x 19 inch.

b. Thirty each, 9 inch x 25 inch.

c. Twenty each, 9 inch x 37 inch.

8. Two each No. 1 insulated gauge plates for No. 8 power operated switch location.

9. Two each No. 2 insulated gauge plates for No. 8 power operated switch location.

10. Full dimension insulation tie pads for the above 4 switch gauge plates.

C. Switch points shall be matched to the appropriate stock rail and numbered accordingly.

D. Switch points and stock rail supplied as spare parts shall be 2 ft. longer than the corresponding rails furnished as part of the turnout components.

E. Spare parts are to be delivered at the time of delivery of the items to be installed. VTA will provide the location for delivery of the spare parts, which will be within 20 mi., of the project installation site.

F. No spare parts are required for any of the diamond crossing types.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Special trackwork shall be installed as specified in Section 34 11 28, Special Trackwork Construction.

3.02 WARRANTY

A. Contractor shall furnish, and extend to VTA, manufacturer's warranty against all manufacturing defects in addition to Contractor's standard 1-year warranty for materials and installation.

END OF SECTION 34 11 23

SECTION 34 11 26

BALLASTED TRACK PRIMARY CONSTRUCTION

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for the installation of ballasted primary track for the light rail track.

B. The construction of ballasted track shall include:

1. Hauling of construction materials.

2. Welding of rail for continuous welded rail (CWR) construction.

3. Construction of ballasted track.

The above construction is encompassing and includes all pertinent trackwork related items associated with track construction such as the welds, bonded and non-bonded insulated joints; rail cutting and stress adjustment; tamping, surfacing, lining and gauging and other operations necessary to construct an acceptable completed track structure.

1.02 REFERENCED STANDARDS

A. American Railway Engineering and Maintenance-of-Way Association, AREMA, Manual for Railway Engineering.

B. American Railway Engineering and Maintenance-of-Way Association, AREMA, Portfolio of Trackwork Plans.

1.03 SUBMITTALS

A. The following submittals shall be made by the Contractor:

1. Detailed descriptions of construction method Work Plan 90 days prior to commencing trackwork required for the work specified in this Section.

2. Survey of the track for acceptance.

3. Test results of electrical resistance.

1.04 QUALITY ASSURANCE

A. To determine the acceptability of the installation, the Contractor shall make a survey of the track and provide the Resident Engineer with a copy for review. Deviations from the Drawings that exceed tolerances specified in Section 34 11 10, Track Installation General Requirements, shall be corrected by the Contractor at no additional cost to VTA.

1.05 MEASUREMENT AND PAYMENT

A. Measurement: Ballasted Primary Track shall be measured by the track foot measured horizontally along the centerline of each track.

B. Payment: The contract price paid per track foot for Ballasted Primary Track shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Ballasted Primary Track including but not limited to the following:

1. Furnishing, placing, consolidating, and finishing ballast

2. Furnishing and installing filter fabric under the ballast

3. Furnishing and installing ties with track fastening devices and associated hardware

4. Furnishing and installing rail; fastening and destressing rail; surfacing and aligning track

5. Installing and fastening emergency guard rails as indicated in the Plans

C. Ballasted Primary Track shall be installed complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 MATERIALS

A. The following track materials shall be furnished by the Contractor and additional items necessary to construct an acceptable completed track structure.

1. Subballast: Section 34 11 84.

2. Ballast: Section 34 11 83.

3. Running Rails: Section 34 11 15.

4. Concrete Ties and Fastenings: Section 34 11 33. Concrete cross ties and fastenings to be used for this project shall be all new.

5. Bonded Insulated Joints: Section 34 11 93.

6. Metal Tags (to mark the superelevation): See Section 34 11 10, Track Installation General Requirements.

7. SubSurface Drainage System Materials (Underdrain Pipes) and geotextile fabric: Section 33 40 00, Storm Drainage Utility.

8. Emergency Guard Rail on ballasted Type D crosstie

   a. AREMA Class I, II, or III second-hand rail, 115RE rail, and joint bars acceptable to VTA, shall be installed as single or double inner emergency guard rail. New track bolts, nuts, and spring washers shall be supplied for the joint bars.

   b. Emergency guard rail fixation 7/8 in. insert bolts to be embedded on crosstie shall be ASTM A 307 Grade A carbon steel.

c. Guard rail base plates, rail stop plate and rail clip plate shall be ASTM A 36 steel with holes drilled, not punched. Minimum dimensions shall be as shown on the Contract drawing.

d. Nuts shall be ASTM A 563 Grade A heavy hex with UNC threads galvanized in accordance with ASTM A 153.

e. Medium split lock washer shall be galvanized in accordance with ASTM A 153.

f. Crane rail clips shall be Foster Rail Clip No. 128 or No. 62 (as appropriate to the rail section), Harmer one-piece rail clip No. 62 or approved equal.

PART 3 – EXECUTION

3.01 GENERAL

A. Construct ballasted track in accordance with applicable requirements of Section 34 11 10, Track Installation General Requirements, as supplemented herein, and as indicated on the Contract Drawings.

3.02 SUBGRADE PREPARATION

A. Refer to the requirements of Section 34 11 84, Subballast, for subgrade preparation.

3.03 SUBSURFACE DRAINAGE (UNDERDRAIN PIPES) AND GEOTEXTILE FABRIC INSTALLATION

A. Installation of underdrain pipes and geotextile fabric shall be in accordance with Section 33 40 00, Storm Drainage Utility.

3.04 PLACEMENT OF SUBBALLAST

A. Subballast shall be distributed, placed, and compacted in accordance with Section 34 11 84, Subballast.

3.05 PLACEMENT OF BALLAST

A. Prior to placement of ballast, rutting and other damage to the subballast shall be corrected.

B. Uniformly distribute a base layer of ballast over the subballast and compact before tie distribution.

1. Compact initial layer of ballast over the entire ballast section as indicated on the Standard Drawings.

2. Limit the base layer of ballast to 6 to 8 inches deep ready to compact without further shaping.

3. 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. A preliminary ballast layer shall not be spread for yard and secondary tracks. Avoid damage to existing facilities including sub-drains, stub-ups, conduits, and other structures.

4. Ballast finish: The top of the base ballast layer shall be a level, flat plane, uniformly compacted prior to cross tie distribution.

3.06 PLACEMENT OF CONCRETE OR TIMBER CROSS TIES AND TIMBER SWITCH TIES:

A. Except as modified herein; handle concrete or timber cross ties and timber switch ties, transport and store in accordance with the current AREMA standards.

1. Use only approved lifting devices that will not damage the tie.

2. Transport cross ties and switch ties in a horizontal position and brace to prevent movement that could cause damage.

B. Transport the concrete cross ties from the storage area to the job site, where the ties shall be distributed and properly spaced on the compacted base layer of ballast. Space concrete cross ties in accordance with the following criteria as indicated on the Contract Drawings.

1. Concrete cross ties shall be spaced 30 inches center to center, except as noted below, measured at centerline of track or high outside rail on curves.

2. In curved track with radius equal to or less than 1000 feet, concrete cross ties shall be spaced 27 inches center to center, measured at high outside rail.

3. Spacing for concrete cross ties at approach slab installations and at crossings shall be as shown on the Contract Drawings.

C. Transport the timber cross ties from the storage area to the job site, where the ties shall be distributed and properly spaced on the compacted base layer of ballast. Space cross ties in accordance with the following criteria as indicated on the Contract Drawings.

1. Timber cross ties shall be spaced 24 inches center-to-center, measured at centerline of track, or high outside rail on curves.

D. Transport timber switch ties to the job site, where the ties shall be distributed and properly spaced on the base layer of ballast in accordance to Section 34 11 28, Special Trackwork Construction.

3.07 RAIL INSTALLATION

A. Lay, join, and anchor CWR in accordance with Section 34 11 10, Track Installation General Requirements.

3.08 SURFACING AND ALIGNING

A. After the skeleton track has been installed, place ballast in the tie cribs and shoulders of the track structure to restrain movement of the ties due to temperature changes in the CWR. Unload ballast in sufficient quantities that will form a high shoulder and will fill the tie cribs and provide an adequate amount of ballast for the initial track lift, plus a surplus as required to continue to hold the track in line after the initial track lift.

B. Track surfacing shall be by methods that will prevent undue bending of the rail, straining of the joints, and damaging or loosening the spring clip fastenings. The amount of track lift shall neither exceed 4 inches nor endanger the horizontal and vertical stability of the track. The track shall be raised so that a final lift shall not be less than 1 inch or more than 3 inches when bringing the track to the final surface. Complete final surfacing and aligning of the track after the track has been initially surfaced and aligned, fastened, and joined together by specified method.

C. Have restraining rail in place for final tamping, surfacing and lining operation.

D. After the track has been finally raised, lined and surfaced, the rails shall be refastened within the specified zero thermal stress temperature range. Clips, insulators, and rail pads shall be thoroughly cleaned of dust, dirt, and grindings prior to refastening of rail. Ties and fastening devices damaged during the surfacing operation shall be replaced with new ties and fastening devices at no additional cost to VTA.

E. The final raising and aligning operations shall fill cribs and shoulders with ballast to within 1 inch below the base of rail. Provide a minimum of 1-inch clearance between metallic portions of the track structure and ballast.

F. Discontinue surfacing when the ambient temperature is higher than 95º F or the rail temperature exceeds 100º F.

G. Perform tamping with a squeeze vibratory type power tamper. Control of the power tamper's tamping cycle shall ensure the maximum uniform compaction of ballast around the track. Uniformly tamp ballast under both sides of each tie, directly under each running rail for a distance of 18 inches on both sides of the rail. Tamping will not be permitted at the center of the tie, but fill the cribs with ballast. For each tie, proceed with tamping simultaneously inside and outside both running rails on both sides of the tie. Mechanically tamp the total track length including approach slab area track zones. Tamper blades shall not penetrate to a depth that would damage the surface of the ballast mats and the approach slab.

H. Compact ballast shoulders with a vibratory shoulder compactor. Continue compacting until the ballast is firmly interlocked and the surface is true and unyielding, displaying no deformation or movement under the compaction equipment. Protect catenary foundations, drainage lines, inlets, and electrical conduit from damage during tamping and compacting.

I. After the final surfacing and lining of track has been completed, dress the ballast to conform to the ballast sections indicated on the Contract Drawings. Reslope subballast outside the toe of slope of ballast that has been fouled or disturbed by the Contractor's operations to the indicated cross sections on the Contract Drawings.

J. The final surface and alignment of track shall be within the ballasted track installation tolerances specified in Section 34 11 10, Track Installation General Requirements.

3.09 EMERGENCY GUARD RAIL INSTALLATION

A. Install single or double emergency guard rails for the protection of LRV and structures at location shown on the contract drawings.

3.10 ELECTRICAL TEST

A. Perform track-to-earth electrical resistance tests at ballasted track construction at a minimum of one test for every 1000 feet of completed track.

B. Track-to-earth electrical resistance test shall be in accordance with Section 34 11 40, Track-to-Earth Resistance Tests.

C. Undertake corrective measures at locations that do not meet the track-to-earth electrical resistance requirements, as specified. The corrective measures shall extend to the next tested location that meets the specified requirements. The corrective measures shall require removal and replacement of insulating materials in the track, at the Contractor's expense, until the requirements of Section 34 11 40, Track-to-Earth Resistance Tests are met.

D. Retest the track-to-earth electrical resistance at the corrected locations, as specified.

END OF SECTION 34 11 26

SECTION 34 11 27

DIRECT FIXATION TRACK CONSTRUCTION

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for constructing direct fixation track. Standard direct fixation track shall use a second pour method of construction on aerial guideway structures using direct fixation fasteners (DFF) to fix rails directly to the second pour concrete plinth.

B. Direction fixation track construction shall include track plinth concrete, reinforcing steel, and all other materials and equipment required for direct fixation track.

C. Related Sections:

1. 03 05 15 Portland Cement Concrete
2. 03 20 00 Concrete Reinforcing
3. 03 62 00 Non-Shrink Grouting
4. 34 11 00 Trackwork Installation General Requirements
5. 34 11 15 Running Rails
6. 34 11 36 Direct-Fixation Fasteners.
7. 34 11 44 Thermite Rail Welding
8. 34 11 93 Miscellaneous Trackwork Elements.

1.02 REFERENCED STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO):

1. T277 Standard Method of Test for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration.

B. American Concrete Institute (ACI):

1. 211.1 Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete.
2. 301 Specifications for Structural Concrete.
3. 304R Guide for Measuring, Mixing, Transporting, and Placing Concrete.
4. 304.2R Placing Concrete by Pumping Methods.

5. 318 Building Code Requirements for Structural Concrete.

C. American Society for Testing and Materials (ASTM):

1. A615 Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.

2. A615M Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.

3. C33 Standard Specification for Concrete Aggregates.

4. C94 Standard Specification for Ready-Mixed Concrete

D. State of California, Department of Transportation (Caltrans), Standard Specifications:

1. Section 51 Concrete Structures.

E. National Ready Mixed Concrete Association (NRMCA):

1. Standards for Operation of Truck Mixers and Agitators.

F. Truck Mixers Manufacturers Bureau (TMMB):

1. Truck Mixers, Agitator and Front Discharge Concrete Carriers Standards.

1.03 SUBMITTALS

A. The Contractor shall make all submittals in accordance with the requirements of Special Conditions SC-6 and SC-51 and as specified herein.

B. Submit working drawings describing step-by-step method of direct fixation track construction indicated on the Plans and specified herein.

C. Submit concrete mix designs, strength verification, materials, notarized Certificates of Compliance, and other required data on proposed concrete mix for track concrete 30 calendar days before beginning concrete work at the Worksite.

D. Submit rebar detail drawings indicating placement, tying, dolby placement and clearances to form work and direct fixation fastener bolts or inserts. Provide rebar lists showing number, lengths and bending and provide mill certificates for rebar steel.

E. Submit working drawings of direct fixation track plinth concrete installation.

F. Submit samples of admixtures for concrete, 30 days in advance of planned use.

G. Contractor shall verify working drawings and proposed installation procedures by installing a demonstration section of direct fixation track. The demonstration section shall be not less than 100 ft of single track. The demonstration section shall be performed at a location acceptable to VTA and shall become a part of the direct fixation rack construction specified herein. Acceptance of the working drawings and installation procedures will be contingent upon VTA's review and acceptance of the completed demonstration section. Contractor shall be responsible for correcting any deficiencies not meeting the requirements of these technical specifications including removal and replacement of unacceptable materials and workmanship. Demonstration section shall be approved by VTA before installation of any other direct fixation track.

H. Before starting construction of direct fixation track, Contractor shall submit plan for repair or replacement of individual direct fixation anchorage assemblies and concrete bearing surfaces which do not meet the requirements of these technical specifications. Repair plan shall include determination of proper placement for anchorage assemblies, core drilling or other removal of failed anchorage assemblies or inserts, leveling or repairing voids in fastener seating area, and specifications and installation methods for silica sand epoxy grout for installation of replacement anchorage assemblies and inserts.

1.04 TRACKWAY

A. Measurement: Direct Fixation Track shall be measured by the track foot measured horizontally along the centerline of each track.

B. Before start of construction of the Work, VTA will provide as-built survey of structure surface and alignment for each trackway confirming acceptable base conditions for the Work of this Contract.

1.05 MEASUREMENT AND PAYMENT

A. Measurement: Direct Fixation Track shall be measured by the track foot measured horizontally along the centerline of each track.

B. Payment: The contract price paid per track foot for Direct Fixation Track shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Direct Fixation Track including but not limited to the following:

1. Furnishing and placing second pour plinth concrete
2. Placing cast-in-place anchor bolt female inserts or core and drill epoxy anchor bolts
3. Furnishing and placing shims
4. Furnishing and installing direct fixation rail fasteners
5. Furnishing and installing rail; fastening and destressing rail; surfacing and aligning track

D. Direct Fixation Track shall be installed complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 TRACK PLINTH CONCRETE

Except as modified herein, concrete shall be as specified in Section 03 05 15 Portland Cement Concrete and modified by requirements specified in this Section.

A. Water/cement ratio shall be the ratio by weight of water to all cementitious materials and shall be 0.40 maximum. Cementitious materials comprise cement, fly ash and micro-silica.

B. Portland Cement for track plinth concrete shall be Type II (High-Early), 500 lb/yd^3.

C. The minimum 28 day strength of all track plinth concrete shall be 4350 psi.

D. Fly ash shall be 100 lb/yd^3 and shall comprise 15 percent to 20 percent of total cement requirement.

E. Aggregate:

1. Coarse aggregate shall have loss in the Los Angeles abrasion testing machine of not more than 50 percent. The coarse aggregate shall be graded within the following limits:

Sieve Size	Percent Passing
3/4 in	100
1/2 in	90 - 100
3/8 in	0 - 100
No. 4	0 - 15
No. 8	0 - 5

2. Grading limits for combined aggregate shall be within the following limits:

Sieve Size	Percent Passing
3/4 in	100
1/2 in	90 - 100
3/8 in	45 - 100
No. 4	35 - 60
No. 8	27 - 45
No. 16	20 - 35
No. 30	12 - 25
No. 50	5 - 15
No. 100	1 - 5
No. 200	0 - 2

3. Fine aggregate shall be either natural sand or manufactured sand, and shall conform to ASTM C33.

F. Water shall be potable and shall contain nothing deleterious to the chemical action of cement. Chloride concentration shall be less than 300 ppm.

G. Admixtures:

1. Water-reducing: Water-reducing admixtures shall be VTA-approved.

2. Plasticizer: Sika Chemical Corporation Plastiment, or VTA-approved equal, in accordance with the manufacturer's recommendations. Plasticzer shall be added at the Worksite only.

3. Micro-silica: 9 percent of the weight of the cement, 45 lb/yd^3 of concrete, dry weight.

4. Air-entraining admixtures shall not be used.

5. Admixtures containing chlorides shall not be used.

H. The slump for track concrete shall not exceed 4 inches.

I. Mix Designs:

1. Design of concrete mixes, including recommended amounts of admixtures and water to be used, shall be obtained from a qualified independent testing laboratory engaged and paid by Contractor and approved by VTA.

2. Test reports shall be submitted for trial mix design chloride permeability tests performed in accordance with AASHTO T277. Make and test 6 concrete specimens. The average of 6 test results shall be no higher than 1 kC, and no single test result shall be higher than 1.2 kC.

3. Selection of mix proportions shall conform to the applicable provisions of ACI 211.1 to produce dense, homogenous, impermeable concrete not susceptible to cracking from plastic shrinkage, heat of hydration, or other causes and complying with ACI 301 and ACI 318M, as applicable.

4. For each mix design indicate manufacturer's name, brand, type and quantities of admixtures included.

5. Pumped concrete shall be designed in accordance with the applicable recommendations of ACI 304R and ACI 304.2R, and shall include strengths and slumps.

6. Aggregate source shall be indicated for both coarse and fine aggregates for each mix design.

7. VTA will have final approval of mix designs.

J. Batching, Mixing and Transporting:

1. Batch, mix and transport portland cement concrete in accordance with the applicable requirements of ACI 301, Chapter 7 and ACI 304R. Provide central-mixed, shrink-mixed or truck-mixed concrete in accordance with requirements of ASTM C94. Use the mixing and transporting equipment conforming in type, capacity and manner of operation to NRMCA Standards for Operation of Truck Mixers and Agitators and TMMB Truck Mixers, Agitator and Front Discharge Concrete Carriers Standards.

2. Central-mixed concrete shall be transported to the Work in truck agitators or truck mixers operating at agitating speed.

3. Shrink-mixed concrete that has been partially mixed at the central plant shall be transferred to a truck mixer and shall comply with the requirements for transit-mixed concrete, with no credit to the total in the total number of revolutions at mixing speed allowed for partial mixing at the central plant.

2.02 REINFORCEMENT

A. Except as modified herein, steel reinforcement shall be as specified in Section 03 20 00 Concrete Reinforcing and as indicated on the Plans. Reinforcement bars shall be ASTM A615/A615M, Grade 60.

B. Unless otherwise indicated or permitted by VTA, splices shall be staggered not less than 30 bar diameters.

2.03 DIRECT FIXATION RAIL FASTENERS AND SHIMS

A. Direct fixation rail fasteners and shims shall be as indicated in Section 34 11 36, "Direct Fixation Track Fasteners."

2.04 RUNNING RAIL AND APPURTENANCES

A. Running rail and appurtenances will be furnished in accordance with Section 34 11 15, "Running Rails."

2.05 SILICA SAND EPOXY GROUT

A. Epoxy-Resin System: shall be as indicated in Section 34 11 36, "Direct Fixation Track Fasteners."

PART 3 – EXECUTION

3.01 TOLERANCES

A. The gauge, cross level, superelevation, and horizontal and vertical alignment of direct fixation track shall be as indicated on the Plans and as specified herein and in Section 34 11 10, "Trackwork Installation General Requirements." Tolerances for direct fixation track construction shall be as specified herein. The difference in elevation of 2 adjacent direct fixation fastener bearing seats on the same rail adjusted for grade shall not exceed 1/16 inch.

B. Anchor bolts for installation into threaded anchor inserts shall provide at least 1-1/4 in. of threaded engagement in final configuration with or without shim plates, shall be torqued to the manufacturer's requirements, and shall meet the installation requirements specified herein.

C. Concrete finish tolerances:

1. Concrete Surface Flatness: Maximum 1/16 in. gap between 16 in. straight edge and concrete surface all around.

2. Elevation of Top Face of Anchor Insert Embedded in Concrete: 0 in. above or 1/16 in. below top surface of concrete.

3. Voids in Bearing Surface of Concrete: No void greater than 1/2 in., and total area of voids less than 10 percent of total bearing area of fastener.

3.02 RAIL FASTENER ANCHORAGE ASSEMBLY LOCATION

A. Direct fixation fastener anchorage assemblies shall be located to provide fastener spacing for standard direct fixation track in accordance with the Plans. Anchorage assemblies shall be installed in conformance with manufacturer's installation procedure.

B. Direct fixation fastener spacing shall not exceed 30 inches, plus or minus 1/4 inch, center to center for both tangent and curved tracks. Spacing may be reduced as necessary to provide clearance to rebar or end of plinth sections. When spacing of direct fixation fasteners is reduced, fastener assembly on opposite rail shall be spaced equally to remain opposite each other.

C. The center of the anchorage assemblies shall not be located closer than 6 in. to the edge of transverse construction joint, drainage chase, contraction joints, and expansion joints. Contractor is permitted to relocate fasteners to meet this requirement, in accordance with Article 3.06A, herein.

D. The center of the anchorage assemblies shall not be located within 6 in. of the lateral edge of track concrete.

3.03 ANCHOR BOLT INSTALLATION

A. Depending upon the type of direct fixation fastener installed, anchor bolts requiring installation before placement of second pour plinth concrete shall be installed as indicated in 3.04D, herein. Anchor bolts requiring installation after placement of second pour plinth concrete shall be installed as indicated in this article.

B. Direct fixation fastener body shall not be used as template independently or by attachment to running rail for the purpose of layout and fabrication for installation of second pour plinth concrete or for placing of silica sand epoxy grout for core drilled installation of female inserts.

C. Rail fastener anchor bolts shall be installed in cored holes. Pull-out strength of installed anchor bolts shall be 144,000 psf minimum. For verification, Contractor shall test pull-out strength and furnish test results of 2 anchor bolts installed in the demonstration section at locations randomly selected by VTA.

D. Immediately before installation of anchor bolt, hole shall be cleaned and dried with compressed air.

E. Anchor bolts shall be installed in the holes within an angle of +/- 1 degree of vertical and spaced to suit the rail plate bolt holes. A template shall be used to maintain anchor bolt locations during installation. Bolts shall be positioned laterally to meet embedded track tolerances.

F. Silica sand epoxy grout shall be placed in holes according to manufacturer's recommendations in such a way as not to disturb the alignment of anchor bolts. Template shall be left in place until grout is strong enough to prevent accidental displacement of anchor bolts.

G. Misaligned anchor bolts shall be removed and reinstalled. Contractor may core larger hole to reinstall anchor bolt.

H. Anchor bolts not meeting requirements specified in this Section and in Section 34 11 36, "Direct Fixation Fasteners," shall be removed and replaced. Misaligned anchor bolts shall be replaced as specified in Article 3.03G, herein.

I. Following installation and cure of anchor bolts in silica sand epoxy grout, Contractor shall assemble rail fixation fastener as recommended by the manufacturer and as specified Article 3.04, herein.

3.04 TRACK PLINTH CONCRETE PLACEMENT

A. Except for modifications indicated herein and on the Plans, concrete placement for track plinth concrete shall be in accordance with Section 51 of the Standard Specifications, and these technical specifications.

B. Existing concrete to receive track plinth concrete for direct fixation track shall be roughened by sand blasting, or an approved alternate method. The abrasive blast shall clean and roughen the hardened concrete surface and expose the aggregate. Exposed reinforcing steel shall be cleaned. An epoxy bonding agent shall be placed on the roughened concrete invert in accordance with Section 03 62 00 Non-Shrink Grouting.

C. Longitudinal and transverse reinforcing steel shall be placed as indicated on the Plans and shall be supported as indicated in Section 03 20 00 Concrete Reinforcing, before concrete is placed and shall be secured against displacement within +/- 1/4 in. Minimum concrete cover on all reinforcing steel shall be 1-1/2 in.

D. Direct fixation fastener anchorage assemblies shall be held by templates at their required final position before pouring second pour plinth concrete. Anchorage assemblies shall be installed in accordance with the fastener manufacturer's recommendations and within the vertical and horizontal tolerances specified by the fastener manufacturer and accepted by VTA. Anchorage assemblies shall be positioned as required to achieve the location requirements of Article 3.02, herein. Reinforcing steel that conflicts with the proper positioning of fastener assemblies shall be adjusted, relocated or supplemented as necessary to conform to the requirements for reinforcing steel. Existing reinforcing steel may be bent to obtain clearance only with the approval of VTA on-site at the time of the work on a case-by-case basis. Direct fixation fastener shim plate, base plate insulating pad and/or running rail shall not be used as part of the templates or system for positioning anchorage assemblies or threaded inserts.

E. Joints in second pour plinth concrete shall be located at actual expansion and construction joints in the existing slab and at drainage chases as indicated on the Plans.

F. Forms shall conform to the requirements of Section 51 of the Standard Specifications, and these technical specifications. Forms shall be constructed of wood, metal, or approved equivalent, and shall be anchored securely. Forms shall be leak proof and shall retain concrete in place during the placing and curing of concrete. Care shall be taken to prevent spillage and leakage of concrete on slab structures. Spillage and leakages shall be immediately removed. The top of the track plinth concrete shall be constructed at the specified elevation for installing track to the finished alignment as specified in Article 3.01, "Tolerances," of this Section and as indicated on the Plans, and shall ensure a uniform bearing seat across the entire concrete surface for each rail fastener base. Direct fixation rail fastener bodies shall not be used to hold anchorage assemblies in place during the placement of track plinth concrete. Anchorage assemblies protruding more than 0.04 in. or recessed more than 0.08 in. from the top of the concrete surface are not acceptable. Forms shall remain in place for 24 hours or until the concrete has achieved a compressive strength of 144,000 psf.

G. Concrete temperature shall be maintained between 39ºF and 90ºF. Concrete shall be mixed, delivered to the joints, and placed within 90 minutes from the time of cement introduction to the mixture.

H. The concrete shall be placed continuously between transverse joints in a manner that will prevent the undesirable effect of overworking. The concrete shall be placed by means that result in concrete free of voids and air pockets. When the fastener bearing seats are covered during the curing of the concrete, not less than 5 percent of the fastener bearing seats as selected by VTA will be exposed to determine the existence of voids. When a single void is greater than 1/2 in. across, or when the total area of voids exceeds 10 percent of the fastener's bearing area, bearing seats shall be repaired or replaced as required by VTA. Repairs shall be made by filling the void area with an epoxy grout acceptable to VTA.

I. Concrete shall be placed to the tolerances specified in Section 51 of the Standard Specifications. When the track plinth concrete is poured below the indicated elevation, Contractor shall use direct fixation rail fastener shims as specified in Section 34 11 36, "Direct-Fixation Track Fasteners," to obtain the finished elevation. When the concrete is poured above the finished elevation, Contractor shall grind track plinth concrete surface as required to obtain the finished elevation.

J. Fasteners shall not be anchored until VTA has inspected and accepted the quality of fastener bearing seats and until the concrete has attained its 28-day compressive strength or until directed by VTA. Loads shall not be placed on track plinth concrete until the specified 28-day compressive strength has been obtained.

K. Concrete finish work shall provide 100 percent support of direct fixation fastener insulating pads. A minimum of 1 in. clearance shall be provided below base of rail to surface of concrete plinths. Direct fixation insulating pads shall not be used with running rails as a template to fabricate track at the time concrete pour is performed but shall be assembled on top of concrete plinth after concrete work is completed.

L. Concrete finish work shall provide level (0%) cross slope for non-superelevated tracks or with the corresponding cross slope for tracks with superelevation as indicated in the Plans. All direct fixation tracks shall be constructed with rail cant of 1:40, which shall be obtained by the installation of the direct-fixation track fasteners Assemblies.

M. Concrete finishing and repair work after the direct fixation fastener assemblies are installed shall not cover, contact, or bridge to the sides or ends of shim plates, elastomer pads, or rail plates.

3.05 ANCHORAGE ASSEMBLY TESTS

A. Two bolts on insert in 1 anchorage assembly in each 26 ft of track, as selected by VTA, shall be subjected to the Restrained Pull-Out test specified below. Failure of 1 anchorage assembly shall be sufficient cause for VTA to reject the entire concrete pour of which the defective anchorage assembly was a part. Testing shall occur no sooner than the date the concrete has achieved its specified 28-day strength and no later than 45 days after the date the concrete was poured.

1. Procedure: A steel plate with a hole in the center 1/2 in. in diameter larger than the top of the insert shall be placed over the anchorage assembly on the concrete test block surface. The anchor bolt shall then have an upward vertical load of 25,000 lbf applied, held for a minimum of 1 minute and then released.

2. Acceptance Criteria: There shall be no evidence of failure from causes including but not limited to slippage and cracking of the concrete to assembly bond at the indicated loads.

B. Restrained Pull-Out Test: A steel plate with a hole in the center 1/2 in. in diameter larger than the top collar of the insert shall be placed on the pedestal pad. An anchor bolt shall be installed to the manufacturer's recommended torque. Apply an upward vertical load, starting at 1000 lbf and increasing to 20,000 lbf at a rate of 1000 lbf/s. Apply load to the anchor bolt with the reaction force bearing against the steel plate. Repeat the test on one other bolt. Acceptance criteria will be no evidence of slippage or cracking of concrete, or failure of bond between the insert, grout and concrete in VTA's sole opinion.

C. Unrestrained Pull-Out Test: Apply a vertical pull-out load on an anchor bolt in such a manner that no restraining load is applied to the concrete pedestal within a radius of 6 in. from the center of the bolt. Load application shall start at 1000 lbf and shall be increased until a load of 10,000 lbf is reached. Acceptance criteria will be no evidence of concrete cracking or failure of bond between either of the two bolts or inserts and the concrete in VTA's sole opinion.

D. Torsion Test: Subject an anchor bolt to a torque at least 100 percent greater than the design installation torque submitted with the installation requirements. Hold the load for 3 minutes and then release. Repeat the test on one other anchor bolt. Acceptance criteria will be no evidence of failure of the bond between either of the two bolts or inserts and the concrete.

E. Remedies:

1. Acceptance Criteria: There shall be no evidence of failure from causes including but not limited to slippage and cracking of the concrete to assembly bond at the indicated loads.

2. Remove defective anchorage inserts and damaged concrete, replace concrete, and furnish and install new inserts.

F. Minimum electrical resistance between uncoated portion of installed anchor bolt and ground shall be 1 MΩ. Contractor shall test each bolt. Resistance measurements shall be recorded and delivered to VTA. Anchor bolts not meeting the requirements in this Section shall be removed and replaced criteria at no additional cost to VTA.

3.06 RAIL FASTENER LOCATION

A. Direct fixation fasteners shall be installed as indicated on the Plans. Fasteners shall be clean and free from concrete and other substances that could reduce the electrical insulation of the rail from the track plinth concrete or bridge deck concrete. Fasteners shall be installed in pairs opposite each other within a longitudinal tolerance of 1 in. and at right angles to the centerline of track. One fastener shall be under each running rail at the specified spacing measured on the centerline of the track for primary track, except at rail joint locations. In primary track the maximum fastener spacing shall be 30 in. Fasteners shall be designed with a lateral adjustment feature having a range of +/- 1/2 in. The range of adjustment shall be for both regauging and aligning of the track. Fasteners shall be installed in such a manner that after final gauging and aligning of the track, not less than 1/2 in. of the lateral adjustment range remains for tightening of the gauge to compensate for future rail wear and not less than 1/4 in. lateral adjustment remains for widening rail for alignment.

B. Shims may be used for vertical adjustment of the direct fixation fasteners with prior approval from VTA. Not more than 2 shims shall be installed under a direct fixation fastener. No more than 3 fasteners in a row shall have 2 shims. Shims shall be supplied in 1/8 in. and 3/8 in. thicknesses. Installation of shims shall be in accordance with the direct fixation fastener manufacturer's written recommendations.

3.07 SHIM PLATES

A. Direct fixation fastener assemblies should be installed on second pour concrete pedestals to exact elevations without the use of height adjustment shim plates. However, if unavoidable for satisfactory installation, shim plates may be used to raise fasteners to the exact height to support fully the running rail.

B. Steel shim plates shall be of 1/8 in. and 3/8 in. nominal thickness.

C. Not more than 2 shim plates and not more than 1/2 in. of shim height shall be installed under a direct fixation fastener. Not more than 3 fasteners in a row shall have 2 shim plates.

D. Installation of shim plates shall be in accordance with the manufacturer's written instructions for installation and maintenance of shim plates.

E. Surplus shim plates shall be returned to VTA at the completion of direct fixation track construction.

F. Quantities of shim plates supplied to Contractor for use in the Work are as shown on VTA-approved supplier shop drawings. If, due to inadequate concrete finish work, additional quantities of shim plates are required for installation on this Contract to obtain the track surface tolerances, Contractor shall be responsible for procuring and installing additional specified shim plates at no additional cost or time delay to the Work.

3.08 LAYING CONTINUOUS WELDED RAIL

A. Rail fastener anchorage assemblies shall be tensioned sufficiently to prevent displacement during laying continuous welded rail. After final alignment and profile are achieved, anchorage assemblies shall be fully torqued to the tension recommended and in accordance with the procedure specified by the direct fixation fastener manufacturer. Tension in anchorage assemblies shall be checked by torque wrenches. Torque wrenches shall be calibrated by tightening, in a device capable of indicating actual bolt tension, no less than 3 typical bolts from each lot to be installed. Power wrenches shall be adjusted to stall or cut out at the selected tension. When 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 a tightening motion when torque is measured.

B. Track installation tolerances shall be as specified herein and in Section 34 11 10, "Trackwork Installation General Requirements." Laying and destressing of CWR shall be as specified herein and in Section 34 11 26, "Ballasted Primary Track Construction."

C. The rail in direct fixation track shall be installed and anchored in a manner which will produce zero thermal stress in the rail at 100ºF, +/- 43ºF.

3.09 ANCHORING CWR

A. Anchoring CWR in direct fixation track shall be accomplished by installing such devices as furnished by the fastener manufacturer for the purpose of securing the rail on the fastener. Anchoring shall be in accordance with the fastener manufacturer's written recommended installation procedure and Section 34 11 26, "Ballasted Primary Track Construction."

B. The entire fastener shall be supported on a solid base with full contact between concrete surface, shim plates (if used), elastomeric pad, rail plate, and base of rails. Direct fixation fastener assembly shall not be in compression or tension more than 1/16 in. If there is more than 1/16 in. difference in elevation between 2 adjacent fasteners, shim plates shall be used or grinding of concrete shall be performed for vertical adjustment.

C. Unless differing installation requirements are provided by the direct fixation fastener manufacturer, installation torque on each anchor bolt shall be 200 lbf·ft to 300 lbf·ft, and shall ensure bolt tension and clamping load in excess of 14,000 lbf.

3.10 FINAL CLEAN-UP, ALIGNMENT AND TRACK INSPECTION

A. All concrete splatter and grout shall be removed from the rails, rail attachment hardware, direct fixation fastener plates and insulating pads.

B. Final alignment and track inspection shall be as specified in Section 34 11 10, "Trackwork Installation General Requirements."

END OF SECTION 34 11 27

SECTION 34 11 28

SPECIAL TRACKWORK CONSTRUCTION

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for special trackwork installation.

B. The construction of ballasted special trackwork shall include:

1. Hauling of construction materials.
2. Welding of special trackwork rail joints.
3. Construction of special trackwork.

The above construction includes pertinent special trackwork related items associated with special trackwork items such as thermite welds; bonded insulated joints; tamping, surfacing, lining and gauging, tie drilling, and other operations necessary to construct an acceptable completed special trackwork structure.

1.02 REFERENCED STANDARDS

A. American Railway Engineering and Maintenance of Way Association, Manual for Railway Engineering, herein referred to as the AREMA Manual.

B. American Railway Engineering and Maintenance of Way Association, Portfolio of Trackwork Plans, herein referred to as the AREMA Portfolio.

C. American Society for Testing and Materials (ASTM):

ASTM D1248 Specifications for Polyethylene Plastics Molding and Extrusion Materials.

1.03 SUBMITTALS

A. The following submittals shall be made by the Contractor:

1. Detailed descriptions of construction method Work Plan 90 days prior to commencing trackwork required for the work specified in this Section.
2. All special trackwork installation tolerance inspection reports as per specified herein and electrical testing results in accordance with, Section 34 11 40.

1.04 QUALITY ASSURANCE

A. To determine the acceptability of the installation, the Contractor shall make a survey of the special trackwork and provide VTA Representative with a copy of the report. Deviations from the Contract Drawings that exceed tolerances specified shall be corrected by the Contractor at no additional cost to VTA.

B. Switch points shall mate and rest under the undercut stock rail and provide a continuous contact with stock rail the length of the machined point rail face adjacent to the stock rail.

C. Switch points shall bear on all slide plates as shown by grease marks and feeler gages in the thrown operating position.

D. Operation of switch point shall be unrestricted and allow for smooth switch machine operation with current draw to suit the switch machine to be installed by the Systems contractor.

E. Track Tolerances: Refer to Section 34 11 10, Track Installation General Requirements for the tolerances for ballasted track.

F. Turnout Tolerances

1. Switch point location: Plus or minus 1/4 inch of the engineering station.

2. Maximum switch point stagger: 1/4 inch.

3. Lead: Plus or minus 1/2 inch.

4. Layout of control switch ties at point of switch and 1/2 inch point of frog: Normal to centerline of tangent track and within plus or minus 1/8 inch.

5. Spacing between switch ties under the switch and frog: Plus or minus 1/4 inch, without accumulation.

6. Spacing between the balance of the switch ties: Plus or minus 1/2 inch, without accumulation.

7. Gauge tolerance in turnout: Plus or minus 1/16 inch.

G. Product Delivery, Storage and Handling

The Contractor shall handle VTA furnished special trackwork materials in a manner that will prevent damage during loading, unloading, storing, transporting, and installing

1.05 MEASUREMENT AND PAYMENT

A. Measurement: Special Trackwork turnouts and crossovers shall be measured by the each unit installed.

B. Payment: The contract price paid per each unit for Special Trackwork turnouts and crossover shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work required for the full installation of Special Trackwork turnouts and crossovers complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 MATERIALS

A. The Contractor will supply the special trackwork turnouts and crossovers materials including timber switch ties and fastening as shown on the Contract Drawings and in accordance with Section 34 11 23, "Special Trackwork".

B. The following materials necessary for complete installation of special trackwork shall be furnished by the Contractor, including but not limited to:

1. Subballast: Section 34 11 84.
2. Ballast: Section 34 11 83.
3. Thermite Rail Welding 34 11 44.
4. Bonded Insulated Joints: Section 34 11 93.
5. Running Rails: Section 34 11 15. For additional running rail within the turnout
6. As needed additional or to be modified special trackwork material including timber ties: Section 34 11 23.
   a. As needed additional or modifications of special trackwork materials, including timber ties, for proper installation of switch machine shall be in accordance with the requirements of Section 34 11 23 and as per specified herein.

C. Other materials

1. Wood preservative to treat holes drilled in timber switch ties. Submit manufacturer's recommendations for applications.
2. Furnish a dry graphite lubricant for application to the riser plates. The lubricant shall have low electrical conducting properties.

D. Switch Machines shall be in accordance with Section 34 42 25.

E. Rail Bonding within special trackwork limit shall be in accordance with Section 34 42 24.

PART 3 – EXECUTION

3.01 GENERAL

A. Construct ballasted special trackwork in accordance with the requirements of Section 34 11 10, Track Installation General Requirements and Section 34 11 26, Ballasted Track Construction.

3.02 PLACEMENT OF SWITCH TIES

A. Carefully distribute timber ties and properly place on the compacted initial layer of ballast or pre-assemble timber and steel components off-site, transport and place at the final location. Space ties and align within the limits of special trackwork as indicated on the Contract Drawings. Install ties with wider heartwood face down. Measurement of tie spacing in special trackwork will be made at the centerline of the tangent track, unless specifically indicated otherwise on the Contract Drawings.

B. Place switch ties within specified tolerances.

C. Line tie ends, 4 feet-3 inches from centerline of tangent track.

3.03 INSTALLATION OF SPECIAL TRACKWORK

A. Locate special trackwork units using stationing, coordinates, and alignment of key geometric points as indicated on the Contract Drawings.

B. Position special trackwork plates squarely on switch timbers as needed. Some VTA furnished timber switch ties will be provided with trackwork switch plates positioned in placed on the switch ties.

C. Drill four or five 9/16-inch diameter anchor screw hold down holes to a depth of 5 inches minimum and 6 inches absolute maximum to suit position of plate in proper turnout alignment. Do not bore holes in tie in excess of the number of lag screws to be used. Do not bore completely through tie. Remove debris from holes, and fill holes with wood preservative.

D. Clean ties and plates prior to installing plates to ensure full bearing of the plates on the ties. Install special trackwork plates and insulated gauge plates as indicated within the limits of special trackwork.

E. Hold down lag screw assembly holes shall be used. Start tie plate screws vertically, squared, and torqued straight. Torque lag screw to manufacturer's specified tension. Exercise care to prevent over-torqueing tie plate screws.

F. Mounting bolt penetrating the timber tie on a skew sufficient to damage or split the insulating collar will be rejected. The tie shall be plugged and redrilled for proper installation and damaged collars and pads shall be replaced.

G. Assemble the special trackwork unit using the VTA-provided Shop Drawings. Installation of VTA STW switch ties, switch plates, gauge plates, throw rod and all auxiliary rods in the switch crib area shall be coordinated with VTA Representative for the requirements of switch machine's base fixation on the switch ties extension and the installation of connector and detector rods as per requirement of Section 34 42 25 – Power Switch Machine and Layouts.

H. Install field fabricated bonded insulated joints and thermite weld joints as indicated on the Contract Drawings.

I. Fully clip special trackwork rail to the plates.

3.04 SURFACING AND ALIGNING BALLASTED SPECIAL TRACKWORK

A. Following the installation of special trackwork on the initial layer of ballast, surface the special trackwork and align as specified herein and in Section 34 11 26, Ballasted Track Construction. Uniformly tamp ballast under both sides of each tie, directly under each running rail and edge of special trackwork component for a distance of 18 inches on both sides of the rail. The top of the ballast section shall be approximately 1 inch below the base of the rail throughout special trackwork unit except in the cribs containing switch and operating rods where the ballast shall be a minimum of 2 inches below the bottom of the switch rod. The width and slope of the shoulders shall conform to the appropriate sections indicated on the Contract Drawings.

B. Compact ballast shoulders with a vibrator shoulder compactor in accordance to compacting requirements in Section 34 11 26, Ballasted Track Construction.

3.05 LUBRICATION

A. At the time of installation, lubricate all sliding surfaces of special trackwork assemblies with a dry film graphite lubricant. Grease switch rod clips in accordance with the manufacturer's instructions. Maintain the lubrication specified therein as necessary to ensure proper operation of all components throughout the duration of the construction Contract.

3.06 BONDED INSULATED JOINTS

A. Install in accordance with Section 34 11 93, Bonded Insulated Joints.

3.07 FINAL ALIGNMENT AND INSPECTION

A. The final surface and alignment of special trackwork at matching exist track shall be within the track and turnout tolerances specified for ballasted track construction. After the final surfacing and aligning is completed, dress and reslope the subballast outside the toe of slope of the ballast, as indicated on the Contract Drawings, as required.

B. Throw the switch, check for freedom of movement, clearances, measure force required to open the flangeway to a width of 2.5 inch at the throw rod location.

C. Measure flange way opening clearances (for open and closed point position) at every 2 ft interval at the distance between point-of-switch and center of heel block. Flangeway width tolerance shall be in accordance with the tolerance requirement of Section 34 11 23-Appendix G.

D. Test for electrical isolation as indicated in Section 34 11 26, Ballasted Track Construction.

END OF SECTION 34 11 28

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SECTION 34 11 29

GRADE AND PEDESTRIAN CROSSING TRACK CONSTRUCTION

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for furnishing and installing materials required for at-grade roadway and pedestrian crossing track.

B. Grade and pedestrian crossing track construction includes, but is not limited to, the following work:

1. Furnishing, placing and consolidating an increased depth ballast section.
2. Placing and aligning concrete ties.
3. Laying, welding, aligning, and fastening rail.
4. Furnishing and Installing Grade and pedestrian crossing panels.

C. Contractor shall coordinate with civil contractor for underdrain installation and roadway work within the limits of the grade crossing track construction.

1.02 REFERENCED STANDARDS

A. American Railway Engineering and Maintenance-of-Way Association (AREMA):

1. Manual for Railway Engineering.

B. American Society for Testing and Materials (ASTM):

1. D1751 Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types).

1.03 SUBMITTALS

A. The Contractor shall make all submittals in accordance with the requirements of Special Conditions SC-6 and SC-51 and as specified herein.

B. Submit:

1. Detailed description of installation procedures required for the work specified in this Section.
2. Submittals required for track construction as specified in Section 34 11 26, "Ballasted Primary Track Construction."
3. Submittals required for materials as specified in Section 34 11 33, “Concrete Ties,” Section 34 11 15, "Running Rails," and Section 34 11 93, "Miscellaneous Trackwork

Elements."

4. Panel layout at each crossing including final crossing lengths.

5. Schedule for crossing installation. At locations where construction of grade crossing track requires full or partial closure of street or highway, Contractor's work schedule shall provide hour-by-hour start and completion details for each operation noted in Article 1.04 herein. Site specific work Plans for grade crossing construction shall be subject to review and approval of VTA and may require review and approval by jurisdictional authorities. Refer to Section 01 55 26, "Traffic Control," for additional requirements.

6. All manufacturers' and Contractor's warranties.

1.04 SEQUENCING AND SCHEDULING

A. The following is a list of major activities required for the installation of grade and pedestrian crossings.

1. Locate existing utilities within crossing Worksite.
2. Install detour and construction signs in accordance with approved traffic control Plans.
3. Put up barricades and close intersection as specified on the Plans.
4. Saw cut existing pavement, as appropriate.
5. Remove existing pavement and unusable subgrade materials, as appropriate.
6. Place and remove trench plates as required during installation process.
7. Grade and compact existing ground or subgrade.
8. Install underdrains and support systems if required.
9. Install geotextile.
10. Place and compact subballast material.
11. Install filter fabric.
12. Place and consolidate first layer of ballast material.
13. Install skeleton track sections.
14. Install temporary rail joints.
15. Place final ballast, lift, line, and surface track.
16. Check track line and cross level.
17. Install grade and pedestrian crossing panels.
18. Check panel line and cross level.

19. Install expansion joint filler.

20. Install and/or replace paving to conform to existing pavement after placement of filter fabric on ballast.

21. Apply traffic markings.

22. Cleanup Worksite.

23. Remove barricades

24. Remove construction and detour signs.

1.05 MEASUREMENT AND PAYMENT

A. Measurement: Grade and Pedestrian Crossing Track will be measured by the track foot, measured horizontally along the centerline of each track. Measurement limits shall be defined by the length of crossing panel installed, including end restraints.

B. Payment: The contract price paid per track foot for Grade and Pedestrian Crossing Track shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Grade and Pedestrian Crossing Track including, but not limited to the following:

1. Construct primary track structure as specified in Section 34 11 26, “Ballasted Primary Track Construction,” within the limits of at-grade roadway and pedestrian crossing track.

2. Grinding off of all raised lettering or characters on top surface of Type C concrete ties, and furnishing and installation of crossing panels.

C. Grade and Pedestrian Crossing Track shall be installed complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 TRACK MATERIALS

A. Track materials for ballasted track within the limits of grade and pedestrian crossing track construction shall be as specified in Section 34 11 26, "Ballasted Primary Track Construction.”

2.02 GRADE AND PEDESTRIAN CROSSING PANELS

A. Panels for grade and pedestrian crossings shall be concrete crossing panels as specified in Section 34 11 93, "Miscellaneous Trackwork Elements.”

2.03 FILTER FABRIC

A. Filter fabric shall be as specified in Section 34 11 93, "Miscellaneous Trackwork Elements.”

2.04 EXPANSION JOINT FILLER

A. Expansion joint filler shall conform to the specifications of ASTM D1751.

2.05 SPECIAL TOOLS

A. Furnish all special tools used to install the crossings.

2.06 END RESTRAINTS

A. Affix end restraints to the outer end panels on each track in accordance with the manufacturer's VTA-approved shop drawings.

PART 3 – EXECUTION

3.01 TRACK CONSTRUCTION

A. Construct ballasted track with Type C grade crossing ties within grade and pedestrian crossing track limited as indicated in the Plans. Track structure for grade and pedestrian crossings shall be constructed as ballasted primary track as specified in 34 11 26, "Ballasted Primary Track."

3.02 CROSSING PANEL INSTALLATION

A. Grade and Pedestrian Crossing: Construct grade and pedestrian crossings to the alignment shown on the Plans, as specified in these technical specifications, and in accordance with the AREMA Manual.

1. Prepare the road crossing trackbed as shown on the Plans and as specified in these technical specifications.

2. Construct track as specified in Article 3.01 A.

3. Before placement of concrete crossing panels, the track shall be in the correct location and in acceptable condition as specified in Section 34 11 10, "Trackwork Installation General Requirements."

4. Before and after placement of concrete crossing panels, verify that ballast is maintained at 1 in. below base of rail.

5. Abrasion pads 1/4 in x 8 in shall be placed on top of the concrete crossties before placement of the concrete crossing panels. Abrasion pads shall be attached to crossties with 2-component, solvent-free, moisture insensitive epoxy-resin system 1:1 or 1:2 adhesive.

6. Concrete panels including rubber filler shall be installed in accordance with the manufacturer's installation instructions and recommendations.

7. Length of crossing panels at each crossing shall extend beyond limits of crossing (as shown on the Plans) a minimum of 1 ft and a maximum of 3 ft.

8. Tie spacing shall be shown on Contractor's shop drawing crossing plans as 18 in +/- 1 in, measured at the centerline of the track and spaced radially in curves. Tie spacing shall be adjusted as necessary to allow panel ends or joints in crossing panels to fall on the center of tie, +/- 1 in.

9. If Contractor's operations in constructing grade and pedestrian crossing use temporary steel trench plates, plates shall not come in direct contact with concrete crossing panels. Warped or twisted trench plates shall not be used.

10. Permanent installation of concrete crossing panels requires adjacent panels to be welded together. If Contractor's initial installation does not include welding of panels together before releasing the grade and pedestrian crossing to street or on-track traffic, Contractor shall be fully responsible for protection of panels from damage and for any adjustments, repairs, or replacement required to reset panels to proper fit before final welding together.

11. Final installation of concrete crossing panels shall not result in any gaps in end-to-end fit or surface-to-surface greater than 1/4 in. Except at track flangeways, gaps between rubber filler material and rail head and between one section of filler rubber to the next shall not exceed 1/4 in.

12. Concrete crossing panels that are higher than top of rail shall be corrected at the time of installation of the panel. The running surface of each panel, when installed, shall be at the top of running rail to 1/8 in below the top of running rail.

13. Separation material shall be furnished and installed on the pavement side of all field panels to provide a bond breaker. The bond breaker material shall extend from top of pavement to bottom of tie.

14. Use of "cutback" shall not be allowed as temporary paving at grade crossings where concrete panels are being installed.

15. Contractor operations during construction or at any time after concrete crossing panels are installed shall not allow any steel wheel or caterpillar tracked machine or steel tools to contact or damage concrete crossing panels. Panels showing spalling or cracking, however minor, before final acceptance of track will be rejected and shall be removed and replaced by Contractor at no cost to VTA.

16. Following acceptance of track surface and alignment, and final acceptance of panel installation and paving, Contractor shall install end restraints on the outside of each outer concrete crossing panel set on each track to prevent longitudinal movement.

17. Ensure that the crossing system has no rail-to-ground connection or rail-to-rail connection that will cause grounding of the rail or shunting of the track signal circuit

B. All raised lettering or characters on top surface of concrete ties shall be ground flush with surface of tie so that panel with bearing pad sits firmly on the tie.

3.03 WARRANTY

A. Contractor shall furnish, and extend to VTA, the manufacturer's warranty against all manufacturing defects in addition to Contractor's standard 1-year warranty for materials and installation.

END OF SECTION 34 11 29

SECTION 34 11 30

LRT VIBRATION MITIGATION TRACK CONSTRUCTION

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for the installation of ballasted LRT vibration mitigation track.

B. LRT vibration mitigation track installation includes:

1. Furnishing, placing and consolidating an increased depth ballast section.
2. Placing and aligning concrete ties.
3. Laying, welding, aligning, and fastening rail.

C. Other aspects of LRT mitigation track construction not specified in this Section shall be as specified in Section 34 11 26, "Ballasted Primary Track Construction."

1.02 REFERENCED STANDARDS

A. American Railway Engineering and Maintenance-of-Way Association (AREMA):

1. Manual for Railway Engineering.

1.03 SUBMITTALS

A. The Contractor shall make all submittals in accordance with the requirements of Special Conditions SC-6 and SC-51.

B. Submit:

1. Detailed description of installation procedures required for the work specified in this Section.
2. Submittals required for track construction as specified in Section 34 11 26, "Ballasted Primary Track Construction."
3. Submittals required for materials as specified in Section 34 11 33, "Concrete Ties," Section 34 11 15, "Running Rails," and Section 34 11 93, "Miscellaneous Trackwork Elements."

1.04 MEASUREMENT AND PAYMENT

A. Measurement: LRT Vibration Mitigation Track will be measured by the track foot, measured horizontally along the centerline of each track.

B. Payment: The contract price paid per track foot for LRT Vibration Mitigation Track shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing LRT Vibration Mitigation Track including, but not limited to the following:

1. Furnishing, placing, consolidating, and finishing the increased depth ballast section
2. Furnishing and installing filter fabric under the ballast
3. Furnishing and installing ties with track fastening devices and associated hardware
4. Furnishing and installing rail; fastening and destressing rail; surfacing and aligning track
5. Installing and fastening emergency guard rails as indicated in the Plans

C. LRT Vibration Mitigation Track shall be installed complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 BALLAST

A. Ballast shall be as specified in Section 34 11 83, "Ballast."

2.02 TIRE SHRED VIBRATION DAMPING LAYER

A. Tire shred vibration damping layer shall be as specified in Section 34 11 85, "Tire Shred Vibration Damping Layer."

2.03 TRACK MATERIALS

A. Track materials shall be as specified in Section 34 11 26, "Ballasted Primary Track Construction."

PART 3 – EXECUTION

3.01 TIRE SHRED VIBRATION DAMPING LAYER

A. The preparation of subgrade and installation of tire shred layer shall be as specified in Section 34 11 85, "Tire Shred Vibration Damping Layer."

3.02 TRACK CONSTRUCTION

A. Construction of LRT vibration mitigation track shall be as specified in Section 34 11 26, "Ballasted Primary Track Construction", with increased depth of the subballast and ballast as indicated in the Plans.

END OF SECTION 34 11 30

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SECTION 34 11 33

CONCRETE TIES

PART 1 – GENERAL

1.01 SUMMARY

This Section includes specifications for the design, manufacture, testing, and handling of monoblock prestressed standard concrete cross ties and grade crossing concrete ties.

A. Two types of concrete ties to be supplied in this project are.

1. Type A – Standard Cross Tie without guard rail fixation.
2. Type C – For grade crossing track.
3. Type D – For Track requiring the use of emergency guard rails.

1.02 REFERENCED STANDARDS

A. American Society for Testing and Materials (ASTM):

ASTM A325	Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM A416/ A416M	Standard Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete
ASTM A536	Standard Specification for Ductile Iron Castings
ASTM A881/	Standard Specification for Steel Wire, Indented, or Low-Relaxation for
A881M	Prestressed Concrete Railroad Ties
ASTM A886/ A886M	Standard Specification for Steel Strand, Indented, Seven-Wire Stress-Relieved for Prestressed Concrete
ASTM C31/ C31M	Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C33	Standard Specification for Concrete Aggregates
ASTM C39/ C39M	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C78	Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
ASTM C109/	Standard Test Method for Compressive Strength of Hydraulic Cement

C109M	Mortars (Using 2-in. or [50-mm] Cube Specimens)
ASTM C114	Standard Test Methods for Chemical Analysis of Hydraulic Cement
ASTM C143/ C143M-98	Standard Test Method for Slump of Hydraulic Cement Concrete
ASTM C150	Standard Specification for Portland Cement
ASTM C172	Standard Practice for Sampling Freshly Mixed Concrete
ASTM C191	Standard Test Method for Time of Setting of Hydraulic Cement by Vicat Needle
ASTM C204	Standard Test Method for Fineness of Hydraulic Cement by Air Permeability Apparatus
ASTM C227	Standard Test Method for Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method)
ASTM C231	Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C260	Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C289	Standard Test Method for Potential Alkali-Silica Reactivity of Aggregates (Chemical Method)
ASTM C295	Standard Guide for Petrographic Examination of Aggregates for Concrete
ASTM C359	Standard Test Method for Early Stiffening of Hydraulic Cement (Mortar Method)
ASTM C430	Standard Test Method for Fineness of Hydraulic Cement by the 45-µm (No. 325) Sieve
ASTM C494/ C494M	Standard Specification for Chemical Admixtures for Concrete
ASTM C586	Standard Test Method for Potential Alkali Reactivity of Carbonate Rocks for Concrete Aggregates (Rock Cylinder Method)
ASTM C618	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C1105	Standard Test Method for Length Change of Concrete Due to Alkali-Carbonate Rock Reaction
ASTM D257	Standard Test Methods for DC Resistance or Conductance of Insulating Materials
ASTM D395	Standard Test Methods for Rubber Property-Compression Set

ASTM D412	Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers-Tension
ASTM D471	Standard Test Method for Rubber Property-Effect of Liquids
ASTM D570	Standard Test Method for Water Absorption of Plastics
ASTM D573	Standard Test Method for Rubber-Deterioration in an Air Oven
ASTM D732	Standard Test Method for Shear Strength of Plastics by Punch Tool
ASTM D1149	Standard Test Method for Rubber Deterioration cracking in an ozone-controlled environment
ASTM D1229	Standard Test Method for Rubber Property-Compression Set at Low Temperatures
ASTM D2240	Standard Test Method for Rubber Property-Durometer Hardness
ASTM D2440	Standard Test Method for Oxidation Stability of Mineral Insulating Oil
ASTM E122	Standard Practice for Calculating Sample Size to Estimate, with Specified Precision, the Average for a Characteristic of a Lot Process

B. American Association of State Highway and Transportation Official (AASHTO)

AASHTO T26	Test for Quality of Water to be Used in Concrete

C. American Concrete Institute (ACI)

ACI 301	Specification for Structural Concrete
ACI 305	Hot Weather Concreting

D. Precast Concrete Institute (PCI)

PCI MNL 116	Quality Control for Plants and Production of Structural Precast Concrete Products

E. American Railway Engineering and Maintenance-of-Way Association Manual for Railway Engineering, AREMA Manual, Chapter 10, Specifications for Concrete Ties.

1.03 DESIGN REQUIREMENTS

A. Design: The Contractor shall prepare the final design of the concrete ties in accordance with AREMA Chapter 10 – Section 1.4 Flexural Strength of Prestressed Monoblock Ties. Concrete ties design can be similar to the design requirements used from the original VTA Tasman Project.

B. Track Configuration: Prestressed concrete cross ties shall be designed for use in ballasted track sections with 115RE rail and 4 feet 8-1/2 inch gauge.

C. Operating Conditions:

1. Multiple unit electrically propelled trains of up to 3 cars shall operate at speeds of up to 55 mph on these ties. The design axle load shall be 28,800 pounds subject to a 30 percent impact factor. Approximate annual vehicle trips shall be 356,000.

2. The compaction of ballast under and around the tie shall be done by using hydraulic or electric activated tamping tools on a production ballast tamper. The cross tie shall resist these tamping forces without spalling of concrete on the sides and bottom corners.

D. Environmental Conditions: Environmental conditions shall be those of the City of San Jose area including a normal ambient temperature range of 50 degrees F to 75 degrees F, with an extreme range from 0 degrees F to 110 degrees F and an average annual rainfall of 16 inches.

E. Design Criteria: The concrete cross ties shall be as shown on the Contract Drawings and shall meet the following requirements.

1. Type A, Type C and Type D cross tie consisting of the following components:

   a. The concrete cross tie complete with embedded rail fastening shoulders.

   b. Two rail insulating elastomeric base pads.

   c. Four fastening spring clips.

   d. Four spring clip insulators.

2. Design strength and electrical isolation requirements.

   a. The concrete cross ties compressive strength shall be 7,000 psi at 28 days.

   b. Concrete cross ties shall be tested to confirm the minimum strength and electrical insulation requirements specified in Part 3 of the specification.

   c. In lieu of the concrete ties strength testing and electrical testing requirements specified in Part 3 of this Section, the Contractor may submit certification from prior successful testing of same type of concrete ties and have proven 5 years performance history.

3. Dimensions

   a. Protrusions: Do not use sharp angles or protrusions that are easily damaged by handling or tamping.

   b. Weight: 800 pounds, maximum.

   c. Length

      i. Type A - minimum of 8 feet 3 inches, exclusive of prestressing tendons.

      ii. Type C - 9 feet 0 inches

      iii. Type D – Length per manufacturers recommended length. Running rail and guard rail separation, 15” minimum. Guard Rail detail per VTA Std Dwg STW-004.

iv. Manufacturing tolerances: Plus or minus 1/8 inch.

d. Width

i. Design Widths

(1) Minimum at ballast bearing area: 10-3/8 inches

(2) Minimum at top surface from rail seat to end of tie: 8 inches

(3) Maximum: 13 inches Manufacturing tolerances: Plus or minus 1/4 inch.

(4) Along the tie, the width at the bottom shall be equal to or greater than the width at the top.

ii. Manufacturing tolerances: Plus or minus 1/4 inch.

e. Depth

i. Design depth: 7-1/2 inches minimum, 9 inches maximum.

ii. Manufacturing tolerances: Plus or minus 3/16 inch.

f. Track Gauge

i. Design gauge shall be 4'-8½".

ii. Manufacturing tolerances: The concrete tie and fasteners shall hold track gauge to plus or minus 1/16 inch from that specified, exclusive of mill tolerance in rail. The centerline of the tie shall be within 1/2 inch of the centerline of the track gauge.

g. Rail Cant: Cant the rail seats one in 40 toward centerline of tie. Cants between one in 35 and one in 45 will be permitted as tolerances.

h. Rail Seat Plane: Flat smooth surface within plus or minus 1/32 inch.

i. Differential Tilt of Rail Seats: The differential tilt in the direction parallel to the rail of one rail seat to the other shall not exceed 1/16 inch over a width of six inches.

j. Protrusion of Pretensioning Tendons: 1/8 inch maximum beyond the ends of the ties.

k. Concrete Cover for Prestressing Tendons, Ducts, and Prestressing End Fittings

i. Design dimension: 3/4 inch minimum cover. Measure cover from outside of embedded items to surface of concrete.

ii. Manufacturing tolerances for clear concrete protection (cover) and depth of prestressing tendons:

(1) +1/8 inch for any two rows of tendons and

(2) +3/16 inch for the third row.

l. Surface Finish

i. The top and side surfaces shall present a smooth, uniform appearance. Except at the rail seat, a random scattering of surface voids will not be cause for rejection. Heavy concentrations of surface voids or evidence of improper mixing, vibrating, or curing will be cause for rejection.

ii. The bottom shall have a rough finish such as may be obtained with a broom.

m. Markings: Mark ties with indented or raised letters to indicate the manufacturer, day and year of manufacture, and the words "VTA". A pour indicator button with the year and pour number shall be an acceptable alternative.

n. Rail Clip Toe Loads: The tolerances of the ties, shoulders, rail clips, insulators, and rail seat pads shall be small enough to prevent excessive variations in the rail clip toe loads. Tolerances that affect the rail clip toe loads shall be approved by the rail clip manufacturer and submitted to VTA Representative for approval.

4. Rail Hold-Down Components

a. Rail hold-down assemblies shall be designed for use with 115 RE rail.

b. Rail hold-down assemblies shall be comprised of as few components as economically and technically feasible for ease of assembly, disassembly, and maintenance. The rail clips, rail seat pads, embedded shoulders, and insulators shall be furnished by the rail clip manufacturer.

c. Design of the ties shall allow the rail clips to be installed or replaced in the field by one worker using hand tools. The clips and fasteners shall be of threadless design.

d. Cross ties shall have, on both sides of the rail base, a positive means of preventing more than 1/8 inch total lateral movement of the rail base relative to the fastener in case of failure or loosening of one or both rail clips. The positive means shall extend at least 3/8 inch above the base of rail in the installed position.

5. Rail Seat Pads

a. Provide rail seat pads compatible with the rail fastening system with a shape that provides positive means of preventing movement of the pad parallel to the rail. Use elastomer pads with a thickness of at least 3/16 inch and not more than 7/16 inch, a width identical to the distance between the shoulder faces on the rail seat (+0, -1/16 inch) and a length one inch longer than the rail seat bearing area (± 1/16 inch). Mark pads in a permanent manner to indicate manufacturer, month and year manufactured, and designation.

b. Rail seat pads shall be manufactured from natural rubber or thermoplastics.

6. Rail Clips

a. The rail clip shall be threadless, one-piece elastic, heat treated, alloy spring steel. One identical clip shall be used on the field and gauge side of the rail at the rail seat.

b. The clips shall be reusable after removal through repeated applications without effect on the operating performance of the system.

c. No part of the clip shall protrude below the tie surface or into the tie.

d. The clip shall not have point contact. The clip shall be such that lateral rail movements within the confines of the shoulders will not produce transverse denting, carving, or scoring of the rail base. The clip shall be such that longitudinal rail slippage will not produce overstressing, bending, twisting, or other damage to the clips, and will not damage the rail.

e. Rail clips and insulators used on rail joint bars need not be identical in design to those used on standard rail, but they shall have similar performance characteristics, shall be made by the same manufacturer, and shall be installed into identical shoulders as the standard rail clip.

7. Insulators between Fastener Hardware and Rails

a. Provide keys between the insulators and the fastener hardware to prevent relative motion in any direction.

b. The insulators shall cover the full widths of the shoulders.

c. Except for surfaces in contact with the rail, the surfaces of the insulators shall be smooth, clearly finished and free of flash. Insulators shall be free of internal defects and cavities.

8. Shoulders

a. Shoulders shall be threadless and shall be designed to provide and maintain proper position and alignment of the rail clip, insulator, rail seat pad, and running rail base.

b. The shoulder shall not be directly anchored to the pretensioned steel.

c. The shoulder shall be ragged stem design to maximize the surface area and pull out resistance.

1.04 SUBMITTALS

A. Submit the following for approval, at least 30 days before the start of fabrication work, to VTA Representative for review.

1. Shop Drawings: Submit shop drawings of each type of tie, including all information necessary for fabrication. Show the dimensions, details, tolerances, finishes, prestressing steel, fasteners, and other embedded items. Describe the procedures for installation and replacement of the fastener components. Show additional information required by VTA Representative.

B. The final design submittal shall be prepared, signed, and sealed by a qualified State of California Registered Professional Engineer engaged by the Contractor.

C. Submit certification that the Contractor's manufacturer of concrete ties has five years experience of long-line production of concrete ties.

D. Submit the method of handling, shipping, unloading, and stacking of concrete cross ties for review and approval at least four weeks before shipping of the concrete cross ties.

E. Provide a concrete cross tie marking scheme for identification of ties and submit to VTA Representative.

F. Provide test records and other required test documentation, for informal review during the in-plant inspection and formally submit prior to shipping of the ties.

G. Certified test reports. Submit test reports and/or certificates of compliance as specified in Articles 3.07, 3.08, and 3.09.

H. Contractor's Drawings and Data

1. The Contract Drawings show the general arrangement and such details as are necessary to provide a comprehensive description of the work to be performed.

2. As indicated below, prepare Shop Drawings including design calculations and other data as may be required by these Specifications as are necessary to adequately perform the work.

3. Furnish design calculations and other required data on standard 8-1/2 by 11 inch sheets, printed on one side only.

4. Submit drawings, data, and schedules in accordance with the specified time requirements. If time requirements are not specified, submit in timely manner to permit no less than 21 days for appropriate review by VTA Representative.

1.05 DELIVERY, HANDLING AND STORAGE

A. Shipping and Handling

1. Ship ties with threaded plastic caps or plugs securely installed in threaded insulated inserts. Securely brace ties for transportation to prevent movement that could cause damage. Ship ties in a horizontal position, braced with wooden spacer blocks so that the top surface or cast-in-place hardware does not contact ties loaded above. Do not load ties higher than the top of the cars nor more than six layers deep. Do not drop or skid ties.

2. Package other parts to prevent damage during shipment and to facilitate handling. Do not mix different parts in the same package.

1.06 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 – PRODUCTS

2.01 CONCRETE MATERIALS

A. Minimum 28-Day Design Compressive Strength: 7,000 psi. Secure samples in accordance with ASTM C 172. Make and cure specimens in accordance with ASTM C 31/31M. Specimens made to check the adequacy of curing and protection of concrete shall be cured entirely under production conditions. Test 6-inch by 12-inch cylinders for strength in accordance with ASTM C 39/C 39M. For each day of production, test at least three cylinders. Minimum transfer requirement is f'ci = 4,500 psi for wire and strand.

B. Minimum 28-Day Flexural Strength: 750 psi. Make specimens in accordance with ASTM C 31/31M. Specimens to check the adequacy of curing and protection of concrete shall be cured entirely under production conditions. Strength tests shall be made on 6 inch by 6 inch by 20 inch beams in accordance with ASTM C 78. Test one beam per every 2,000 ties of production.

C. Cement

1. Cement shall conform to ASTM C 150, Type II or III low alkali (less than 0.60 percent). The false set penetration, when tested in accordance with ASTM C 359, shall not be less than 2 in. initially, 1.38 in. at intermediate times, and 1.57 in. after remix.

2. Separate random samples of cement shall be taken each day of production to represent the cement used on each bed. Each sample shall not be less than one pound and shall be clearly identified with the date and bed number. Each sample shall be kept in airtight containers until the corresponding 28-day cylinder tests have been carried out and results accepted by VTA Representative.

3. Not more than two sources of clinker or ground cement shall be used by the manufacturer during any one month. Cement from each source shall be clearly identified and stored in separate weathertight silos. If two sources of cement are used on one bed, the tests shall be performed on the first batch of concrete made with each cement and thereafter as required. Strength tests shall also be conducted on concrete made with each type of cement.

4. Cement mill certificates shall be provided weekly by each supplier and shall continue the results of the following tests on cement delivered during that week.

   a. Fineness by air permeability (ASTM C 204).

   b. False Set (ASTM C 359) - Penetration at 3, 5, 8, 11 minutes and after remix.

   c. Setting Time (ASTM C 191).

   d. Compressive Strength (ASTM C 109/C 109M) at 1 day, 3 days, and 7 days.

   e. Chemical Analysis (ASTM C 114) - Including SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, SO_3, K_2O, Na_2O, and calculated alkalies as Na_2O equivalent, C_3S, C_2S, C_3A, C_4AF.

   f. Residue on 325 mesh sieve (ASTM C 430).

5. At least once during every three months, a randomly chosen sample of cement from each source used shall be analyzed for alkali content in accordance with ASTM C 114 by an outside testing laboratory.

D. Fine and Coarse Aggregates: AREMA Specifications for Aggregates, Article 1.3, Chapter 8 of the AREMA Manual, except as modified herein. Coarse aggregates shall be gravel, crushed gravel, crushed stone, or a combination thereof.

1. Aggregates shall be natural aggregates complying with ASTM C 33 Class 4S.

2. The manufacturer shall provide evidence that concrete containing aggregate from the proposed source with a cement content and alkali burden similar to the job mix, has a satisfactory service history of at least 5 years. This evidence shall include structures requiring a Class 4S aggregate.

3. The maximum size of aggregate shall be 3/4 inch. If the coarse or fine aggregate is supplied in more than one size, each size shall be stored separately.

4. Washed aggregate shall be allowed to drain, in stockpiles, before use. All aggregates shall be free from ice when used.

5. In addition to the requirements of ASTM C 33, the following tests shall be conducted by an outside testing laboratory.

a. Petrographic examination to ASTM C 295. This shall be conducted on each new source.

b. Evaluation of potential alkali reactivity shall be made according to.

i. ASTM C289 Potential Reactivity of Aggregates (Chemical Method)

ii. ASTM C227 Potential Alkali Reactivity of Cement - Aggregate Combinations (Mortar Bar Test). The alkali content, expressed as sodium oxide plus 0.658 potassium oxide shall be less than 0.6 percent by weight. The mortar bars for testing shall be made with an aggregate/cement ratio by weight of 2.25:1. This test may need to extend over a time period of six months, and should therefore begin early in the Contract period.

c. Evaluation of potential alkali carbonate reactivity. Aggregates containing carbonate shall be tested in accordance with ASTM C 586 and C 1105.

d. Mixing Water: Water shall be potable and free from harmful amounts of oils, acids, alkalis, salts, organic materials, or other substances that may be deleterious to concrete or steel. Mixing water, including that portion of the mixing water contributed in the form of free moisture on aggregates, shall have a chloride ion content of less than 100 ppm. When required, test mixing water in accordance with AASHTO T 26.

e. Admixtures, if used.

i. Air-Entraining Admixtures: ASTM C 260

ii. Accelerating, Retarding, and Water-Reducing Agents: ASTM C 494/C 494M.

iii. Other Pozzolanic Admixtures: ASTM C 618.

iv. Do not use admixtures containing chlorides, fluorides, sulphites, nitrates, or aluminum powder.

E. Cement Content: 600 pounds per cubic yard, minimum.

F. Water-Cement Ratio: 0.45 maximum.

G. Entrained Air: Total air content 3 percent to 5 percent in hardened concrete.

2.02 PRESTRESSING TENDONS

A. General: Prestressing tendons shall be pretensioned and of one of the following types:

1. Wire for tendons in prestressed concrete per A 881 / A 881M.

2. Strand for tendons in prestressed concrete per ASTM A 416, A 886 / A 886M or equal. Do not use strands larger than 7/16-inch diameter.

2.03 RAIL FASTENING IRON SHOULDERS

A. Ductile iron shoulders shall be obtained by the manufacturer and shall conform to ASTM A536 Grade 60-40-18 or 65-45-12. They shall be marked, on non-bearing surfaces above the concrete level, with the part number, supplier's identification and pattern number.

1. The shoulders shall be free from burned-on sand, cracks, cavities, injurious blow holes and other defects. Fins shall be removed from the vertical faces of the head of each shoulder. Fins across the top of the head shall not exceed 1/32 inch and below the head, fins shall not exceed 1/16 inch. At gates, there shall be no cavity in the shoulder more than 1/8 inch below the general surface level.

2. Go and No Go inspection gages shall be used to check that tolerances conform with the iron shoulder drawings. A sampling plan for Acceptable Quality Levels of 1 percent for major dimensions and 4 percent for minor dimensions shall be used (see ASTM E122). The manufacturer shall decide which are major and minor dimensions. These shall be indicated on the shop drawings.

B. Iron shoulders shall be free of mud, oil, loose rust, and other contamination when cast into ties. They shall be rigidly secured in the forms during casting and shall not move within the concrete when the securing device is released. Location within the ties shall comply with the Contract Drawings.

1. The shoulder shall not be directly anchored to the pretensioned steel. The shoulder shall not come in contact with pretensioned steel.

2.04 EMBEDDED ANCHOR INSERTS

A. The anchor inserts shall, as a minimum, conform to ASTM A325, and have a Class 2B thread fit.

B. As part of the insert, there shall be a feature to prevent rotation of the insert after the concrete has reached its design strength. The anchor insert shall have a minimum length of 4 inches and a maximum length of 5 inches and shall have a minimum 3-inch engaging threaded length.

C. In the installed position, the top of the anchor insert shall provide a flat surface parallel to the rail base with a minimum of 1/8 inch bearing width surrounding the anchor bolt hole.

D. Inserts shall be furnished with an installed plug of metal or plastic material to preclude the entrapment of moisture, concrete, or other foreign materials. Removal shall be by using a socket or other common device. Plugs shall be capable of reinsertion, and if reinserted, shall still exclude concrete and other materials from entry.

E. Inserts shall be coated with a uniform epoxy resin insulating coating on exterior surfaces.

1. Coating material shall be 100 percent dry powder epoxy resin such as Scotch Kote Brand Protective Resin No. 203, manufactured by the Minnesota Mining and Manufacturing Company, Corvel Epoxy ECB-1363A, manufactured by the Polymer Corporation, or approved equivalent.

2. The coating application shall be in accordance with the coating manufacturer's recommendations and the following general requirements, or an approved equivalent.

3. Before coating, the insert shall be degreased and cleaned to white metal in accordance with SSPC Specification SP5, White Metal Blast Cleaning.

4. The epoxy coating shall not be thinner than 10 mils nor thicker than 20 mils. Epoxy coating having runs, sags, or chips will not be accepted. Thickness shall be tested by a magnetic mil gauge at not less than two areas of the insert.

5. When tested in accordance with ASTM D2440, epoxy coatings shall have a hardness of not less than 85 nor more than 80 Shore D.

6. The coated insert shall be tested for pinholes and breaks in a weak electrolytic solution. A 100 volt dc electrical current shall be applied between the electrolyte and the insert; the coating will be acceptable if the circuit is not closed when the insert is immersed in the electrolytic solution. The above tests shall be performed by the epoxy coating applicator. The frequency of testing shall be in accordance with a sequential statistical quality control plan developed by the epoxy coating applicator. The plan shall ensure that the average defective rate shall not exceed two percent and that the maximum defective rate shall not exceed five percent. These defect rates shall be demonstrated at a 90 percent degree of confidence.

2.05 RAIL FASTENING COMPONENTS

A. The concrete ties running rail fastening system shall include rail seat pads, spring clips and spring clips insulators.

B. Rail fastening shall be resilient, threadless and detachable. Component part shapes shall be such that they are easily recognizable and are difficult to install incorrectly.

1. Fastening shall be comprised of as few components as economically and technically feasible for ease of assembly, disassembly, and maintenance. The rail clips, railseat pads, and insulators shall be furnished by the rail clip manufacturer.

2. Construct fastenings so that the rail clips can be installed or replaced in the field by one person using hand tools.

3. Construct fastenings so that when the rail clips are removed, the rail may be lifted vertically until it is completely free of the fastening shoulder without disturbing the horizontal or vertical alignment of the shoulder or the adjacent restraining rail bracket.

4. Fastenings shall have, on both sides of the rail base, a positive means of preventing more than 1/8 inch total lateral movement of the rail base relative to the shoulders in case of failure or loosening of one or both rail clips. The positive means of restraint shall extend at least 3/8 inch, but not higher than 1-3/4 inches above the base of rail in the installed position.

C. Rail Fastening Spring Clips

1. Rail clips shall not be dependent on elastomeric components in torsion.

2. One identical clip design shall be used on the field and gauge side of the rail at the railseat. The e-clip type springs clips shall be identical to that used on concrete ties on the existing VTA primary ballasted tracks near Old Ironside Drive and Tasman Drive grade crossings.

3. The clips shall be reusable after removal through repeated applications without effect on the operating performance of the system.

4. No part of the clip shall protrude below the tie surface or into the tie.

5. The clip shall not have point contact. The clip shall be such that lateral rail movements within the confines of the shoulders will not produce transverse denting, carving, or scoring of the rail base. The clip shall be such that longitudinal rail slippage will not produce overstressing, ending, twisting, or other damage to the clips, and will not damage the rail.

6. Rail clips and insulators used on rail insulated joint bars need not to be identical in design to those used on a standard rail. The clips shall clear the joint bar, shall have similar performance characteristics, shall be made by the same manufacturer, and shall be installed into identical shoulders as the standard rail clip. Rail insulated joint bar dimensions are provided in Section 34 11 93, “Miscellaneous Trackwork Elements”.

D. Insulators between fastening shoulder and rails

1. Configuration

   a. Provide keys between the insulators and the fastening shoulder to prevent relative motion in any direction.

   b. The insulators shall cover the full widths of the shoulders.

   c. Except for surfaces in contact with the rail, the surfaces of the insulators shall be smooth, clearly finished and free of flash. Insulators shall be free of internal defects and cavities.

2. Volume Resistivity: 1012 ohm-cm, minimum. Measure in accordance with ASTM D257.

3. Water Absorption at Saturation: Three percent, maximum. Measure in accordance with ASTM D570.

4. Dry Shear Strength: 6,500 psi, minimum. Measure in accordance with ASTM D732.

5. Deformation Under Load: Five percent, maximum. Measure at 2,000 psi and 122 degrees F.

6. Heat Aging: Age for 10 days at 70 degrees C using ASTM D573 as a guide. Compare properties before and after aging at 70 degrees C. The tensile strength shall not decrease more than 10 percent. The Rockwell Hardness shall not change more than five points. There shall be no warping, cracking, discoloration, or exudation of plasticizer.

7. Weatherometer Test: After 1,000 hours with cycled water spray, the yield stress shall be a minimum of 8,000 psi and the tensile strength shall be a minimum of 6,000 psi.

E. Rail Seat Pads

1. Rail seat pads shall conform to AREMA, Chapter 10, Section 1.2.5.

2. Provide rail seat pads compatible with the rail fastening system with a shape that provides positive means of preventing movement of the pad parallel to the rail. Pad thickness shall be at least 3/16 inch and not more than 1/2 inch, with a width identical to the distance between the shoulder faces on the railseat (+0, -1/16 inch) and a length one inch longer than the railseat bearing area (plus or minus 1/16 inch). Mark pads in a permanent manner to identify manufacturer, month and year manufactured, and pad designation.

PART 3 – EXECUTION

3.01 CONCRETE MIX DESIGN

A. Trial mixtures using aggregates, water, cement, and admixtures proposed for the manufacture of the concrete ties shall be made using at least three different water-cement ratios which will produce a range of strengths. For each water-cement ratio, at least three specimens for each day of production shall be made, cured, and tested as described in Article 2.01 and Article 3.02. Each batch of concrete shall be mixed separately in a pan mixer.

B. Design compressive strength at the time proposed for transfer of prestress forces to the concrete shall be no less than 4,500 psi, or higher if so required by the tie design or manufacturing method. Design compressive strength at 28 days shall be not less than 7,000 psi. Design flexural strength at 28 days shall be not less than 750 psi.

C. Aggregates and cement shall be measured by weight. The weight of aggregate shall be based on the saturated surface dry condition corrected for free moisture. Water shall be measured by weight or volume and admixtures shall be measured by volume, unless otherwise directed by the admixture manufacturer.

D. Mix proportions shall be developed using the method of ACI 301, Section 3.9.

E. Restriction on design mix proportions:

1. The cement content shall be not less than 800 pounds per cubic yard.

2. The water-cement ratio shall not exceed 0.40 by weight. Water content shall be kept to the minimum consistent with strength requirements and placement needs.

3. Air content in the plastic concrete shall ensure a minimum 3.5 percent air entrainment in the hardened concrete.

F. The proportions of aggregate to cement shall be such to produce a mixture that will work readily into corners and angles of the form and around the prestressing elements with the assistance of specified vibration, but without permitting the materials to segregate or excess of free water to collect on the surface.

G. The strength tests shall be made at:

1. The age at which transfer of prestress forces shall be made, and

2. 28 days, a curve shall be developed for each design mix showing the relationship between water-cement ratio and compressive strength.

H. Acceptance of trial mix: The maximum permissible water-cement ratio for the concrete mix to be used shall be that shown by the water-cement ratio versus strength curve to produce average strengths of 110 percent of those specified in Article 3.01.B.

3.02 STRENGTH TESTS OF CONCRETE

A. Compressive and Flexural Strength tests shall be made to check the adequacy of the mix proportions and as a basis for acceptance. Samples for compressive test specimens shall be secured in accordance with ASTM C172. Samples for flexural tests specimens shall be secured and 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 entirely under production conditions.

1. Compressive Strength tests shall be made on 6-inch by 12-inch cylinders in accordance with ASTM C39/C39M. For each day of production at least six cylinders shall be prepared two for 28 day testing, and two for checking strength at transfer, and 2 spares.

2. Flexural Strength tests shall be made on 6 by 6 by 20-inch beams in accordance with ASTM C78. Minimum flexural strength (modulus of rupture) at 28 days shall be 750 psi.

3.03 FABRICATION AND FORMS

A. Dimensions and Tolerances: The tie design shall be within the following dimensional limits. The finished tie shall not deviate in any dimension from that shown on the Contract Drawings for the approved tie design by more than the tolerance associated with that dimension.

1. Length

a. Type A - Standard Concrete Cross Tie; 8 feet 3 inches minimum, 8 feet 6 inches maximum, plus or minus 1/8 inch.

b. Type C - 9 feet 0 inches

c. Type D - per manufacturers recommended length.

2. Width of Bottom

a. Type A - Standard Concrete Cross Tie; 10-3/8 inches minimum, 13 inches maximum plus or minus 1/4 inch.

b. Type C and D - Per manufacturer's recommended width of bottom.

3. Width of Top

a. Standard Concrete Tie; 8 inches minimum, 10 inches maximum plus or minus 1/4 inch.

b. Type C and D - Per manufacturer's recommended width of top

4. Depth

a. Standard Concrete Tie; 6-1/4 inches minimum at any location and 8-3/16 inches maximum at the rail seat, plus or minus 3/16 inch.

b. Type C and D- Per Manufacturers recommended depth

5. Track Gauge: 4 feet 8-1/2 inches, plus or minus 1/16 inch, exclusive of rail dimensional tolerances.

6. Rail Cant: 1 in 40, plus or minus 5, towards the center line of the tie.

7. Differential Tilt of Rail Seats: Differential tilt in the direction of the rail of one rail seat to the other shall not exceed 1/16 inch in a width of 6 inches.

8. The centerline of the tie shall be within 1/2 inch of the centerline of track gauge.

9. Chamfer: 1 inch nominal plus or minus 1/2 inch.

B. Method of Production: Monoblock ties shall be manufactured by the long line process.

C. Forms

1. Forms shall be rigid and shall be constructed of material that will result in finished ties conforming to the shape, lines, dimensions and tolerances called for on the Contract Drawings.

2. Forms shall be constructed to permit movement of the tie without damage during release 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 shall be placed on top of tie surface.

3.04 PLACEMENT OF PRESTRESSING STEEL

A. Prestressing force in each of the strands shall be 16,750 pounds +/- 500 pounds.

B. The load shall be applied in two increments. An initial load of approximately 1,000 pounds shall be applied to the individual strands to straighten them, eliminate slack, and provide a starting or reference point for measuring elongation.

C. Prestressing force shall be determined by (1) measuring strand elongation and (2) by either checking jack pressure on a calibrated gauge or by the use of a calibrated dynamometer. The cause of discrepancy that exceeds 5 percent shall be ascertained and corrected. Elongation requirements shall be taken from average load elongation curves for the steel used.

D. Strands shall be stretched either individually or simultaneously. If strands are stretched simultaneously, provision for taking up slack and equalizing stress shall be made individually as required to induce approximately equal stress in each strand.

E. Transfer of force from bulkheads of the pretensioning bed to the concrete shall be accomplished by gradual and simultaneous detensioning of all strands. Exposed strands shall be cut near the tie end. The projection of strands beyond the ends of the ties shall be no more than 1/4 inch.

3.05 MIXING, PLACING, AND CURING OF CONCRETE

A. Preparation for Placing Concrete

1. Prior to the placing of concrete, equipment for mixing the concrete shall be clean, debris shall be removed from spaces to be occupied by the concrete, the forms shall be thoroughly coated with a bond-breaker, and the reinforcement shall be thoroughly cleaned of deleterious coatings. The iron shoulder and prestressing wire shall not be contaminated with bond-breaker or other substance that would interfere with bond development. The forms shall be inspected for alignment and tightness of joints and dimensional accuracy of the position of bulkheads, prestressing steel, and inserts shall be verified.

2. Proportioning of Component 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 either weight or volume.

3. The accuracy of measurement of the various components of concrete shall be within the following limits:

Cement	1%
Water	1%
Fine aggregate	2%
Coarse aggregate	2%
Cumulative aggregate	2%
Admixtures	3%

B. Mixing of Concrete

1. 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.

2. Concrete shall be mixed until there is a uniform distribution of the materials and shall be discharged completely before the mixer is recharged.

3. Optimum mixing time shall be established by the equipment manufacturer's recommendations. Generally, minimum mixing time shall be one minute for batches of one cubic yard or less. This mixing time shall be increased by at least 15 seconds for each cubic yard, or fraction thereof, of capacity more than one cubic yard. Mixing time shall not exceed three times the specified time.

C. Conveying

1. Concrete shall be conveyed from the mixer to the place of final deposit in the shortest possible time by methods that will prevent segregation or loss of materials.

2. Equipment for chuting, pumping, and pneumatic conveying of concrete shall be of such size and design as to assure flow of concrete at the delivery location without segregation of materials.

D. Depositing

1. Concrete shall be deposited as nearly as practical in its final position to avoid segregation due to rehandling or flowing. No concrete that has partially hardened or has been contaminated by foreign materials shall be used.

2. Concrete shall not be placed when the ambient air temperature of the casting room is below 40 degrees F. Concrete shall have a minimum temperature of 50 degrees F, and a maximum temperature of 90 degrees F. When concrete is placed at an ambient temperature of 90 degrees F or greater, the recommendations of ACI 305 shall be followed to prevent rapid drying and other detrimental effects of elevated temperature on fresh concrete.

E. Consolidating

1. Concrete shall be thoroughly consolidated by vibration during placement, and shall be thoroughly worked around the prestressing elements and embedded fixtures and into corners of the forms. Consolidation at the ends of ties is paramount to comply with the void tolerance specified in Article 3.06B.

2. External form vibration supplemented, if necessary, by internal vibration shall be used to obtain uniform mix, and shall be sufficient to yield concrete with a density not less than 148 pounds per cubic foot.

3. Care shall be taken to assure that forms are not damaged during consolidation.

F. Surface Finishing-Bottom of Tie

1. The bottom surface of the tie shall have a rough screeded finish. Indentations as shown on the Contract Drawings shall be pressed into the bottom of the tie prior to setting of the concrete. Two ties, which show the required bottom surface condition, shall be set aside from an early batch as a comparison standard for the acceptance of later ties.

G. Testing Fresh Concrete

1. The first batch on any bed shall be tested and if this requires no adjustment to the mix, a further test shall be made after approximately 25 cubic yards has been poured. If the first batch requires adjustment to the mix each subsequent batch shall be tested until no further adjustment is necessary and then a further batch shall be tested after approximately 25 cubic yards has been poured.

2. Slump: When measured in accordance with ASTM C143/C143M, the slump shall not exceed 2 inches when concrete is placed in the forms.

3. Air Content: When measured in accordance with ASTM C231, the range of air content in the plastic concrete shall ensure a minimum 3.5 percent air void content in the hardened concrete.

4. Temperature: The temperature of freshly mixed concrete shall not exceed 90 degrees F.

H. Curing

1. Immediately after placing and consolidating the concrete, the exposed surface shall be covered with impermeable sheeting.

2. Concrete shall not be placed in forms whose temperature is less than 40 degrees F and the concrete temperature shall not be allowed to fall below 50 degrees F between casting and transfer of prestress.

3. The rate of temperature rise in the concrete shall not exceed 35 degrees F per hour and the maximum concrete temperature shall not exceed 175 degrees F. Transfer of prestress shall not be carried out at a concrete temperature above 135 degrees F. The heating method used shall be such that ties in a bed are at a similar temperature.

4. Curing shall be done in accordance with established procedures to produce concrete strength as specified.

I. Detensioning. Stress transfer shall be performed in a controlled manner with hydraulic jacks. The forms shall be free to move and the stress in wires shall be transferred at the same time and same rate. No wire shall be cut until it is completely detensioned.

3.06 REMOVAL OF TIES FROM FORMS AND FINISHING

A. Ties shall be removed from forms in a manner such as to avoid damage.

B. Surface Finishing

1. Formed surfaces of the finished tie shall have a uniformly dense surface. The surface of the railseat shall have a smooth finish and be free from honeycomb, surface irregularities, and air holes more than 1/8-inch diameter. Other surfaces shall have a smooth finish that may contain honeycomb not to exceed 2 percent of the surface and a maximum void diameter of 1/4 inch.

2. Two ties, which show the required surface finish, and two ties, which show the maximum allowable rail seat defects, shall be set aside as comparison standards for acceptance of ties. These four ties shall be in addition to those for bottom finish comparison.

C. Inspection and Repair of Surface Defects

1. Every tie produced shall be visually inspected by the manufacturer.

2. The surface of the rail seat shall have a smooth, formed finish not inferior to the comparison standards. No rubbing, brushing or other treatment shall be used on the rail seat.

3. Surface conditioning with a mixture of 3 parts sand and 1 part cement mixed with 1 part latex cement mix and 1 part water shall be undertaken on surfaces containing air pockets. The maximum size of any one pocket shall not exceed 3/8-inch diameter by 1/4 inch deep.

4. Ties with voids not deeper than 3/4 inch around not more than 2 end wires shall be repaired with a silicone rubber sealant. Ties with voids beyond this limit will be rejected.

5. Corner breakage less than 1/2 inch deep and 1-1/2 inches along the end faces need not be repaired providing reinforcing wire is not exposed. If the wire is exposed the breakage shall be repaired.

6. Corner breakage from 1/2 to 1-1/2 inches in depth shall be repaired. Corner breakage more than that will be rejected.

7. Prestressing wires protruding more than 1/4 inch beyond the concrete surface of the end of the tie shall be cut back. Sharp ends, which would be hazardous in handling, shall be smoothed or cut back.

3.07 ACCEPTANCE OF DESIGN TESTS FOR CONCRETE TIES

A. Design Tests

1. Prior to approval of the concrete tie design, the following tests shall be performed. The tie samples submitted will be subjected to testing for compliance with these Specifications.

2. From a lot of not less than five ties produced, three ties shall be selected at random for laboratory testing. If required for design testing of the fastening system, the producer shall also furnish a section of a tie or a concrete block with railseat and fastening system identical to the concrete ties furnished for testing. A separate test series shall be conducted for the standard cross tie and the restraining rail cross tie.

3. 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 requirements specified below. Upon satisfactory completion of the examination, two ties, designated as Tie No. 1 and Tie No. 2, shall be subjected to the specified performance tests. The remaining tie, which will be designated as Tie No. 3, will be retained for further test use and as a control for dimensional tolerances and surface appearance of ties subsequently produced.

B. Sequence of Design Tests (Tie No. 1)

1. The sequence of design performance tests using Tie No. 1 shall be as follows:

   a. Railseat positive bending moment test shall be performed on the two railseats designated "A" and "B";

   b. Center Negative Bending Moment Test;

c. Bond Development, Tendon Anchorage, and Ultimate Load Test shall be performed on Railseat A.

C. Rail Seat Positive Bending Moment Test

1. Test procedure and acceptance criteria are shown in Figure 1.

2. Summary of Test: With the tie supported and loaded as shown in Figure 1, a load shall be applied in such a manner as to avoid shock until the stated load is obtained. This load shall be held for not less than three minutes, during this time an inspection shall be made to determine if structural cracking has occurred. A five-power magnifying glass may be used to locate cracks. If structural cracking has not occurred, the requirements of this test will have been met.

3. This test shall be performed on both rail seats on Tie No. 1.

D. Tie Center Negative Bending Moment Test

1. Test procedure and acceptance criteria are shown in Figure 2.

2. Summary of Test: With the tie supported and loaded as shown in Figure 2, a load shall be applied at a uniform rate and in such a manner to avoid shock until the stated load is obtained. This load shall be held for not less than three minutes, during this time an inspection shall be made to determine if structural cracking has occurred. A five-power magnifying glass may be used to locate cracks. If structural cracking has not occurred, the requirements of this test will have been met.

E. Bond Development and Ultimate Load Test

1. Test procedure and acceptance criteria are shown in Figure 3.

2. Summary of Test: With the tie supported and loaded as shown in Figure 3, load shall be applied at a uniform rate and in such a manner to avoid shock and increased until the stated load 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 shall be increased until ultimate failure occurs. The ultimate failure load so obtained shall exceed 47,800 pounds.

F. Sequence of Design Tests (Tie No. 2)

1. The sequence of design performance tests using Tie No. 2 shall be as follows:

a. Rail Fastening Insert Shoulder Pullout and Torque Test shall be performed on all inserts and shoulders;

b. Rail Fastening Uplift Test shall be performed on one rail seat;

c. Electrical Resistance and Impedance Test.

G. Rail Fastening Shoulder and Insert Pullout and Torque Tests

1. Test procedure and acceptance criteria are shown in Figure 4.

2. Summary of Test: The following test shall be performed on each shoulder and insert as indicated in Figure 4 to determine the ability of shoulder and inserts to resist tension and rotation. The stated axial load shall be applied to each shoulder and insert separately and shall be held for not less than three minutes. Each insert shall then be subjected to the stated torque test. The embedded shoulders and inserts 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.

H. Rail Fastening Uplift Test

1. Test procedure and acceptance criteria are shown in Figure 5.

2. Summary of Test: A 19 inch section of 115 RE rail shall be secured to one railseat 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 and method described in Figure 5, an incremental load shall be applied to the tie. The maximum, as determined fastener uplift load, shall then be applied. The inserts shall not pull out or loosen in the concrete and no component of the fastening system shall fracture nor shall the rail be released.

I. Electrical Resistance and Impedance Test (Wet or Dry)

1. Test procedure and acceptance criteria are shown in Figure 5 Test procedure and acceptance criteria are shown in Figure 6.

2. Summary of Test: Secure two short pieces of 115 RE rail to the tie using complete concrete tie fastenings. The rail pieces shall be no longer than the width of the tie. Clean contact points on each rail and attach cables. Clean a contact point on a pretensioned tendon near the middle of one end of the tie and attach a cable (hereinafter designated as a ground). Tests, test methods, procedures, and acceptance criteria shall be in accordance with those shown on Figure 6. The minimum resistance for 500 volts dc shall be 10 megohms when dry and 0.4 megohm when wet. The minimum impedance for frequencies between 20 Hertz and 12 kiloHertz with 50 volts ac applied shall be 10,000 ohms when wet.

3.08 ACCEPTANCE OF DESIGN TESTS FOR FASTENING SYSTEM

A. Fasteners shall be subjected to the acceptance tests as specified below. Failure of fastening system to pass tests will be cause for rejection. Certified laboratory test reports shall be submitted in sufficient detail to VTA Representative.

B. Acceptance of design testing of the fastening system consists of testing of components cast into the concrete tie in addition to tests conducted on the external components.

C. Acceptance design tests for rail seat pad shall consist of the following:

1. Specimens: Perform the following tests on each of two specimens. The specimens shall be manufactured and cured in the same manner as the final product. Use a separate pair of specimens for each test, except the accelerated aging tests. Prior to testing, condition specimens for at least seven days at 73 degrees F and 50 percent relative humidity. Failure of either of the two specimens to meet requirements will be cause for rejection.

2. Hardness: Measure the hardness in accordance with ASTM D2240. The reading on each pad shall be between 50 and 80 durometer, Shore A. Average the two readings and record the average for reference in production testing.

3. Tensile Strength, measured by ASTM D412: 1,500 psi, minimum.

4. Ultimate Elongation, measured by ASTM D412: 250 percent, minimum.

5. High Temperature Compression Set: Using Method B of ASTM D395 with a Type 2 specimen, test for 22 hours at 212 degrees F. The compression set shall not exceed 25 percent.

6. Compression Set at 0 degrees F: Using ASTM D1229, test for 22 hours at 0 degrees F. The specimen thickness shall be 0.25 plus or minus 0.008 in. The compression set at 30 minutes after release (t30 reading) shall not exceed 40 percent.

7. Accelerated Aging: Using ASTM D573, age the elastomer for 48 hours at 212 degrees F. Measure and record the change in hardness, tensile strength, and ultimate elongation. The tensile strength shall not decrease more than 15 percent. The ultimate elongation after aging shall be at least 200 percent and shall be at least 60 percent of the durometer A scale. The durometer A scale shall not vary more than 10 points from pre-aging values.

8. Resistance to Ozone Cracking: Prepare and test the specimens in accordance with ASTM D1149 at a temperature of 104 degrees F and an ozone concentration of 50 pphm. The elastomer shall not exhibit cracking when examined in accordance with ASTM D1149 at the end of a 100-hour exposure.

9. Oil Absorption: Using ASTM D471, conduct one test with ASTM No. 3 oil at 212 degrees F for 70 hours and conduct another test using a different sample with ASTM No. 1 oil at 212 degrees F for 70 hours to determine the volume change of the elastomer. For No. 1 oil, the volume change shall not exceed minus 10 or plus 20 percent. For No. 3 oil, the volume change shall not exceed 100 percent.

10. Volume Resistivity: Apply 100 volts dc for three minutes. The volume resistivity, measured in accordance with ASTM D257, shall be at least 40 x 10^{10} ohm-in.

11. Water Absorption: Using ASTM D471, test 70 hours at 212 degrees F in distilled water. The volume change shall not exceed plus 35 or minus zero percent.

D. Rail Seat Pads - Production Quality Control

1. Batch Control: A batch is defined as the rubber mixed, processed and cured together, not exceeding one day's production. Keep the pads segregated by batch. Perform the following tests on two samples chosen from each batch at random. Use two different specimens for each test. If either of the two samples fails a test, the entire batch shall be either rejected or subjected to the test that the sample failed. Prior to testing, condition specimens for at least seven days at 73 degrees F and 50 percent relative humidity.

2. Hardness: When measured in accordance with ASTM D2240, the hardness shall be within plus or minus five durometer, Shore A, of the average recorded in Article 3.08C.2.

3. Tensile strength, ultimate elongation, high temperature compression set, volume resistivity and water absorption: Test as specified in Article 3.08C.3, 4, 5, 10 and 11 respectively.

E. Acceptance Design Tests for Fastening Assembly

1. The sequence of design tests for the fastening assembly, if required to be conducted on the tie block shall be as follows:

    a. Rail Fastening Repeated Load Test;

    b. Rail Fastening Longitudinal Restraint Test;

    c. Rail Fastening Lateral Restraint Test.

F. Rail Fastening Repeated Load Test

1. Test procedure and acceptance criteria are shown in Figure 7.

2. Summary of Test: A 19 inch section of 115 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. Three million cycles of loading shall be applied in accordance with the loading diagram in Figure 7, alternating downward and upward loads at an angle of 20 degrees to the vertical axis of the rail. Rupture failure of any component of the fastening system shall constitute failure of the test.

G. Rail Fastening Longitudinal Restraint Test

1. Test procedure and acceptance criteria are shown in Figure 8.

2. Summary of Test: After successful completion of the Rail Fastening Repeated Load Test specified above and without disturbing the rail fastening assembly in any manner, the tie and fastening shall be subjected to a longitudinal restraint test. An increasing longitudinal load shall be applied in 400-pound increments as indicated in Figure 8. The load shall be increased until the stated load is reached. The stated load shall be held for not less than 15 minutes. The fastenings shall meet the requirements of this test in either direction of loading. The fastenings will have successfully passed this test if the rail movement is less than 0.125 inch.

H. Rail Fastening Lateral Restraint Test

1. Test procedure and acceptance criteria are shown in Figure 9.

2. Summary of Test: A 19-inch section of 115 RE rail shall be secured to the rail seat using a complete fastening assembly. The entire assembly shall be supported and loaded as indicated in Figure 9. Both restrained and unrestrained lateral load tests shall be performed as described in Figure 9. Inability of the fastening to carry a 20-kip load with 1/8 inch or less of rail translation shall constitute failure of the restrained lateral load test. Rail rotation, gauge widening less rail translation, greater than 1/4 inch under an applied load of 10 kips shall constitute failure of the unrestrained lateral load test. Complete failure of any component of the tie or fastening is cause for rejection.

3.09 DAILY PRODUCTION QUALITY CONTROL TESTS

A. Acceptance Tests

1. At the start of production, a minimum of 6 railseat positive, 6 tie center negative, and 6 shoulder pull-out tests shall be undertaken by the manufacturer on randomly selected ties to establish compliance with these Specifications. After the acceptance test load results are checked, additional loading shall be applied to the ties to produce the first crack greater than 1 inch in vertical length and these loads and crack lengths recorded.

B. Routine Production Testing

1. Routine acceptance testing shall be carried out on all beds cast. One tie selected from every 200 ties or fraction thereof from one form, selected at random from each bed cast, shall be load tested as follows:

   a. Rail Seat Positive Bending Moment Test - Figure 1, at both seats.

2. If structural cracking occurs in 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 requirements, the lot will be accepted;

   b. If either of the retest ties fails to meet the test requirements, the remaining ties shall be tested in accordance with a statistical sampling plan.

3. One tie selected at random from every 200 ties or fraction thereof produced each day shall be subjected to testing the distance from the center of track to the center of rail seats by use of a template, the rail seat configuration and shoulder insert location shall be verified.

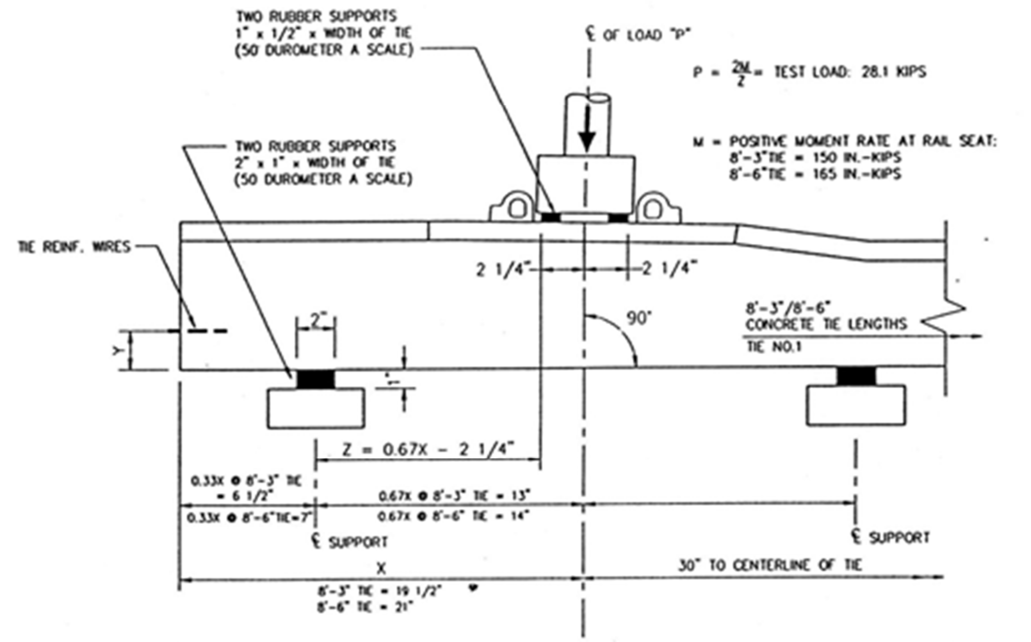
4. One tie per 1000 cast shall be selected at random from those ties previously subjected to the Rail Seat Positive Bending Moment Test (one of every five of such ties) shall additionally be tested for Bond Development.

   a. If strand slippage does not exceed 0.001 inch, the requirements of this test will have been met.

   b. If strand slippage exceeds 0.001 inch, three additional ties shall be tested. If any of the three ties does not meet the requirements of the test, the remaining ties in the lot shall be tested in accordance with a statistical sampling plan.

3.07.C RAIL SEAT POSITIVE BENDING MOMENT TEST

3.07.C.1 THE CONCRETE TIE SHALL BE SUPPORTED IN A HYDRAULIC TESTING MACHINE AS SHOWN BELOW WITH LOADING POINTS SO ARRANGED THAT THE LOAD IS APPLIED AT RIGHT ANGLES TO THE BASE OF THE TIE MIDWAY BETWEEN THE SUPPORTING PADS. (THE "Y" DIMENSION REPRESENTS THE DISTANCE FROM BOTTOM OF TIE TO BOTTOM ROW OF PRESTRESSING WIRES.)



3.07.C.2 A TEST LOAD OF 28.1 KIPS SHALL BE APPLIED AT A RATE NOT EXCEEDING 5 KIPS PER MINUTE. THE LOAD SHALL BE HELD FOR 3 MINUTES, DURING WHICH TIME THE INSPECTION SHALL BE MADE TO DETERMINE IF STRUCTURAL CRACKING HAS OCCURRED. BOTH SIDES OF THE TIE SHALL BE INSPECTED FOR CRACKS. BOTH RAIL SEATS OF THE TIE SHALL BE TESTED.

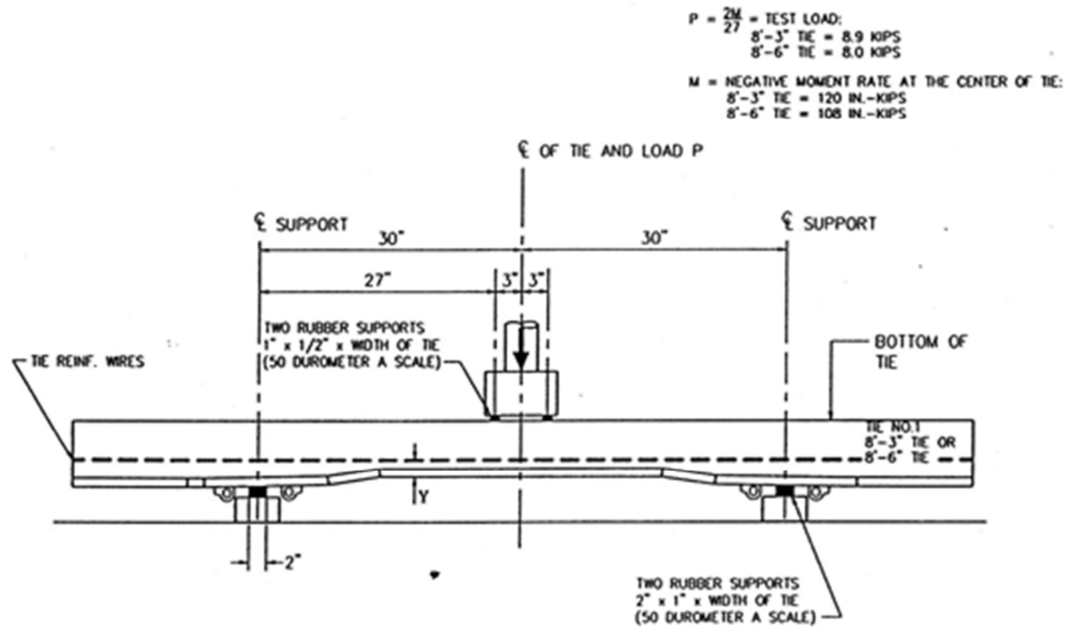
3.07.C.3 ACCEPTANCE CRITERIA

IF STRUCTURAL CRACKING HAS NOT OCCURRED WHEN VIEWED UNDER 5 POWER MAGNIFICATION, THE REQUIREMENT OF THE TEST WILL HAVE BEEN MET. THE ILLUMINATION AT THE SURFACE DURING INSPECTION SHALL BE NOT LESS THAN 125 FOOT CANDLES.

FIGURE 1

3.07.D TIE CENTER NEGATIVE BENDING MOMENT TEST

3.07.D.1 THE CONCRETE TIE SHALL BE SUPPORTED IN A HYDRAULIC TESTING MACHINE AS SHOWN BELOW WITH LOADING POINTS SO ARRANGED THAT THE LOAD IS APPLIED AT RIGHT ANGLES TO THE BASE OF THE TIE MIDWAY BETWEEN THE SUPPORTING PADS.



3.07.D.2 A TEST LOAD OF 8.0 OR 8.9 KIPS (DEPENDING ON TIE LENGTH) SHALL BE APPLIED AT A RATE NOT EXCEEDING 5 KIPS PER MINUTE. THE LOAD SHALL BE HELD FOR 3 MINUTES, DURING WHICH TIME THE INSPECTION SHALL BE MADE TO DETERMINE IF STRUCTURAL CRACKING HAS OCCURRED. BOTH SIDES OF THE TIE SHALL BE INSPECTED.

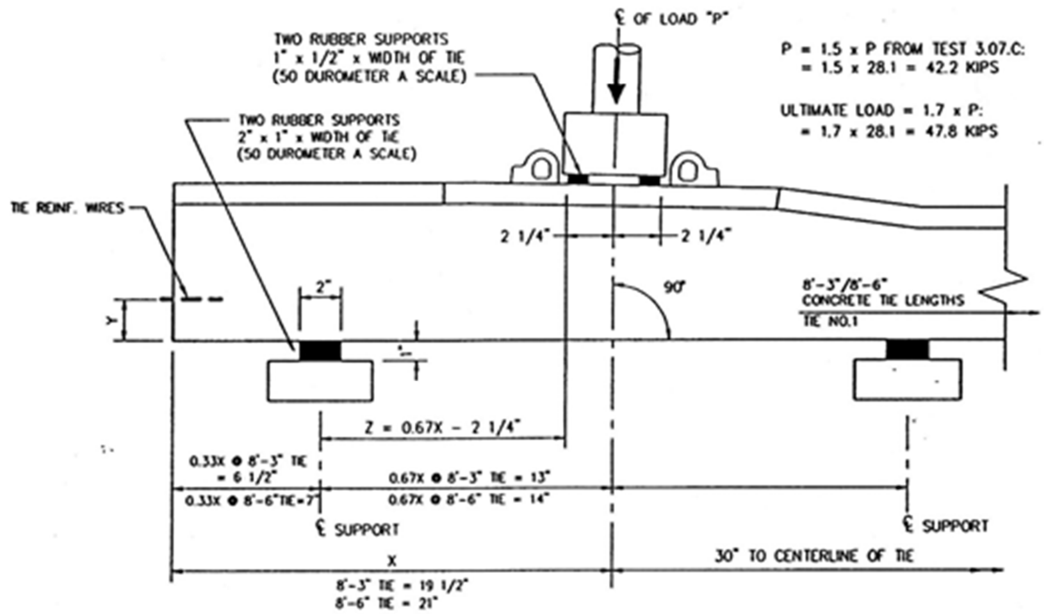
3.07.D.3 ACCEPTANCE CRITERIA

IF STRUCTURAL CRACKING HAS NOT OCCURRED WHEN VIEWED UNDER 5 POWER MAGNIFICATION, THE REQUIREMENT OF THE TEST WILL HAVE BEEN MET. THE ILLUMINATION AT THE SURFACE DURING INSPECTION SHALL BE NOT LESS THAN 125 FOOT CANDLES.

FIGURE 2

3.07.E BOND DEVELOPMENT AND ULTIMATE LOAD TEST

3.07.E.1 THE CONCRETE TIE SHALL BE SUPPORTED IN A HYDRAULIC TESTING MACHINE AS SHOWN BELOW WITH LOADING POINTS SO ARRANGED THAT THE LOAD IS APPLIED AT RIGHT ANGLES TO THE BASE OF THE TIE MIDWAY BETWEEN THE SUPPORTING PADS. (THE "Y" DIMENSION REPRESENTS THE DISTANCE FROM BOTTOM OF TIE TO BOTTOM ROW OF PRESTRESSING WIRES.)



3.07.E.2 BOND DEVELOPMENT TEST

A TEST LOAD OF 42.2 KIPS SHALL BE APPLIED AT A RATE NOT EXCEEDING 5 KIPS PER MINUTE. THE LOAD SHALL BE HELD FOR 3 MINUTES DURING WHICH TIME THE TWO INSPECTION MEASUREMENTS SHALL BE MADE TO DETERMINE IF STRAND SLIPPAGE OCCURS. MEASUREMENTS SHALL BE MADE ON THE OUTERMOST TENDONS OF THE LOWER LAYER USING AN EXTENSOMETER READING TO 0.0001 OF AN INCH.

3.07.E.3 ACCEPTANCE CRITERIA

IF THERE IS NO MORE THAN 0.00001 INCH TENDON SLIPPAGE THE REQUIREMENT OF THE TEST WILL HAVE BEEN MET.

3.07.E.4 ULTIMATE LOAD TEST

CONTINUING FROM THE ABOVE TEST THE LOAD SHALL BE INCREASED UNTIL ULTIMATE FAILURE OCCURS AND THE MAXIMUM LOAD OBTAINED AT ULTIMATE FAILURE SHALL BE RECORDED.

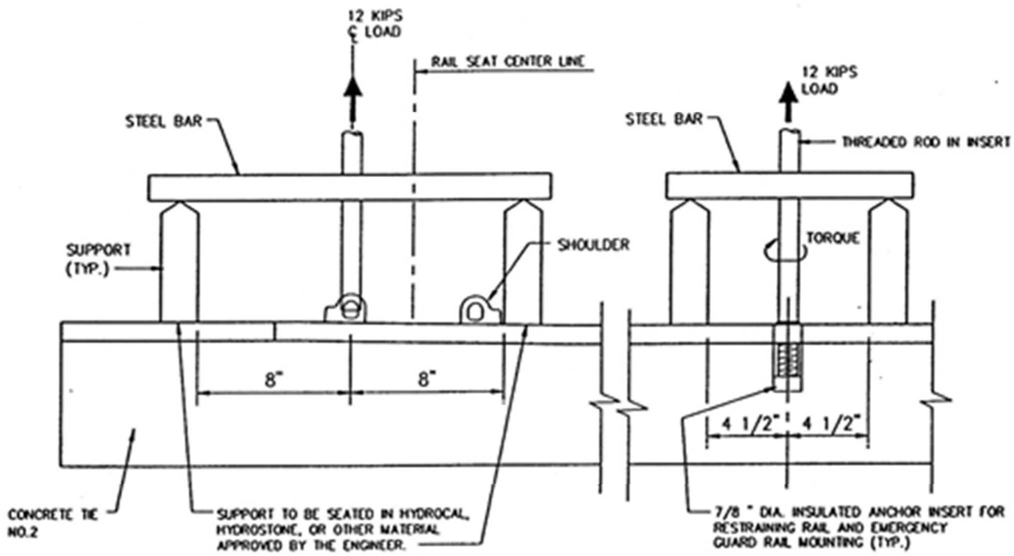
3.07.E.5 ACCEPTANCE CRITERIA

THE MAXIMUM LOAD AT ULTIMATE FAILURE SHALL EXCEED 47.8 KIPS.

FIGURE 3

3.07.G RAIL FASTENING SHOULDER & INSERT PULLOUT & TOURQUE TESTS

3.07.G.1 THE CONCRETE TIE SHALL BE SUPPORTED ON A HYDRAULIC TESTING MACHINE AS SHOWN BELOW WITH LOADING POINTS SO ARRANGED THAT THE LOAD IS APPLIED AT RIGHT ANGLES TO THE RAIL SEAT OF THE TIE. THE TEST SHALL BE APPLIED TO EACH ANGLES INSERT AND SHOULDER SEPARATELY.



3.07.G.2 PULL OUT TEST

A VERTICAL TEST LOAD OF 12 KIPS SHALL BE APPLIED TO EACH SHOULDER AND INSERT AT A RATE NOT EXCEEDING 5 KIPS PER MINUTE. THE LOAD SHALL BE HELD FOR 3 MINUTES, DURING WHICH TIME THE INSPECTION SHALL BE MADE TO DETERMINE IF THE SHOULDER OR INSERT HAS MOVED OR DEFORMED.

3.07.G.3 TORQUE TEST

A TORQUE OF 250 FOOT POUNDS SHALL BE APPLIED TO EACH INSERT. THE LOAD SHALL BE HELD FOR 3 MINUTES DURING WHICH TIME THE INSPECTION SHALL BE MADE TO DETERMINE IF THE INSERT MOVED.

3.07.G.4 ACCEPTANCE CRITERIA

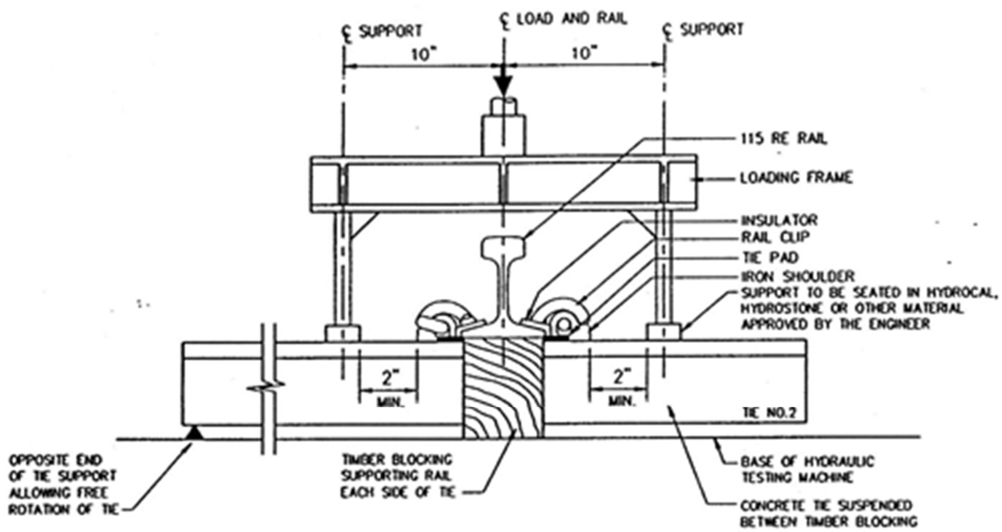
IF SLIPPAGE OF THE SHOULDER OR INSERT, OR ANY CRACKING OF THE CONCRETE, HAS NOT OCCURRED THE REQUIREMENT OF THE TESTS WILL HAVE BEEN MET. MORTAR CRACKING AND SEPARATION OF LAITANCE IN THE VICINITY OF THE INSERT WILL NOT BE CAUSE FOR REJECTION. INABILITY OF THE SHOULDERS OR INSERTS THEMSELVES TO RESIST BOTH THE 12 KIP VERTICAL LOAD AND THE 250 FT. LB. AXIAL TORQUE TESTS WITHOUT PERMANENT DEFORMATION SHALL CONSTITUTE FAILURE OF THE TEST.

FIGURE 4

3.07.H RAIL FASTENING UPLIFT TEST

3.07.H.1 AN 19 INCH LONG SECTION OF 115 RE RAIL SHALL BE SECURED TO ONE RAILSEAT USING A COMPLETE RAIL FASTENING SYSTEM INCLUDING PADS, CLIPS, AND ASSOCIATED HARDWARE, AS RECOMMENDED BY THE MANUFACTURER OF THE RAIL FASTENING SYSTEM.

THE CONCRETE TIE WITH FASTENING SHALL BE SUSPENDED IN A HYDRAULIC TESTING MACHINE AS SHOWN BELOW WITH LOADING POINTS SO ARRANGED ON THE TIE THAT THE LOAD IS APPLIED AT RIGHT ANGLES TO THE BASE OF THE TIE MIDWAY BETWEEN THE LOAD APPLICATION PADS.



3.07.H.2 AN INCREMENTAL LOAD SHALL BE APPLIED TO THE TIE TO DETERMINE THE LOAD "P" (PLUS THE UNSUPPORTED CONCRETE TIE WEIGHT AND FRAME WEIGHT) AT WHICH SEPARATION OF THE RAIL FROM THE TIE PAD OR TIE PAD FROM THE CONCRETE TIE SEAT OCCURS. THIS LOAD "P" SHALL BE RECORDED. THE LOAD SHALL THEN BE COMPLETELY RELEASED.

3.07.H.3 AN UPLIFT TEST LOAD OF THE LESSER OF EITHER 1.5P OR 10 KIPS SHALL THEN BE APPLIED.

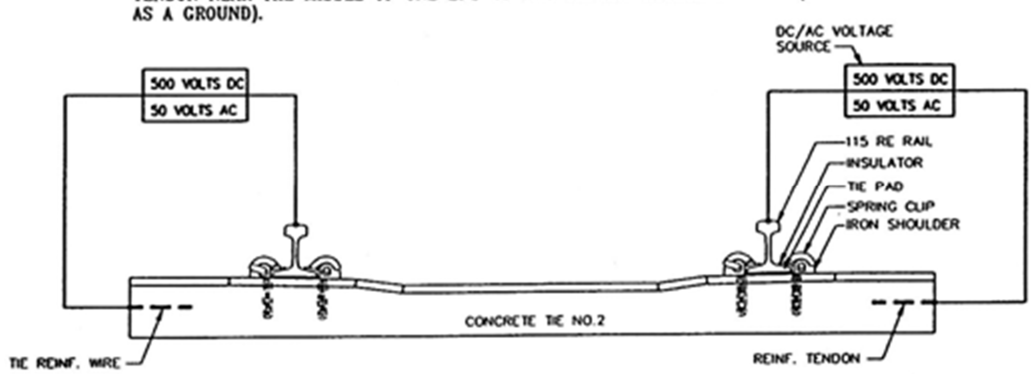
3.07.H.4 ACCEPTANCE CRITERIA

IF THE INSERTS DO NOT PULL OUT OR LOOSEN IN THE CONCRETE AND NO COMPONENT OF THE FASTENING SYSTEM FRACTURES AND THE RAIL IS NOT RELEASED, THE REQUIREMENT OF THE TEST WILL HAVE BEEN MET.

FIGURE 5

3.07.I ELECTRICAL RESISTANCE AND IMPEDANCE TEST

3.07.I.1 SECURE TWO SHORT PIECES OF 115 RE RAIL TO THE TIE USING COMPLETE CONCRETE TIE FASTENINGS. THE RAIL PIECES SHALL BE NO LONGER THAN THE WIDTH OF THE TIE. CLEAN CONTACT POINTS ON EACH RAIL AND ATTACH CABLES. CLEAN A CONTACT POINT ON A PRETENSIONED TENDON NEAR THE MIDDLE OF ONE END OF THE TIE AND ATTACH A CABLE (HEREINAFTER DESIGNATED AS A GROUND).



3.07.I.2 DRY DC RESISTANCE TEST

APPLY 500 VOLTS DC FROM EACH RAIL TO GROUND WITH AN ACCURACY OF PLUS OR MINUS TWO PERCENT.

3.07.I.3 ACCEPTANCE CRITERIA

THE MINIMUM RESISTANCE FOR 500 VOLTS DC SHALL BE 10 MEGOHM (DRY).

3.07.I.4 PREPARATION FOR WET ELECTRICAL TEST

THE COMPLETE RAIL AND TIE FASTENINGS ASSEMBLY SHALL BE IMMERSED IN WATER FOR A MINIMUM OF 6 HOURS AT ROOM TEMPERATURE.

3.07.I.5 WET DC RESISTANCE TEST

WITHIN ONE HOUR AFTER REMOVAL FROM THE WATER, WITHOUT DRYING, TEST THE ASSEMBLY FOR ELECTRICAL RESISTANCE. APPLY 500 VOLTS DC FROM EACH RAIL TO GROUND FOR THREE MINUTES EACH. MEASURE THE RESISTANCE FROM EACH RAIL TO GROUND WITH AN ACCURACY OF PLUS OR MINUS TWO PERCENT.

3.07.I.6 WET AC IMPEDANCE TEST

IMMEDIATELY AFTER REMOVAL FROM THE WATER AND WITHOUT DRYING, TEST THE ASSEMBLY FOR ELECTRICAL IMPEDANCE. APPLY A POTENTIAL OF 50 VOLTS AC FROM EACH RAIL TO GROUND FOR THREE MINUTES AT FREQUENCIES FROM 20 HERTZ TO 12 KILOHERTZ IN INCREMENTS OF 20 HERTZ UP TO 100 HERTZ, THEN IN INCREMENTS OF 200 HERTZ FROM 200 HERTZ TO 1,000 HERTZ AND IN INCREMENTS OF 2 KILOHERTZ FROM 2 KILOHERTZ UP TO 12 KILOHERTZ. THE IMPEDANCE AFTER THREE MINUTES SHALL BE MEASURED WITH AN ACCURACY OF PLUS OR MINUS TWO PERCENT AND RECORDED FOR EACH FREQUENCY.

3.07.I.7 ACCEPTANCE CRITERIA

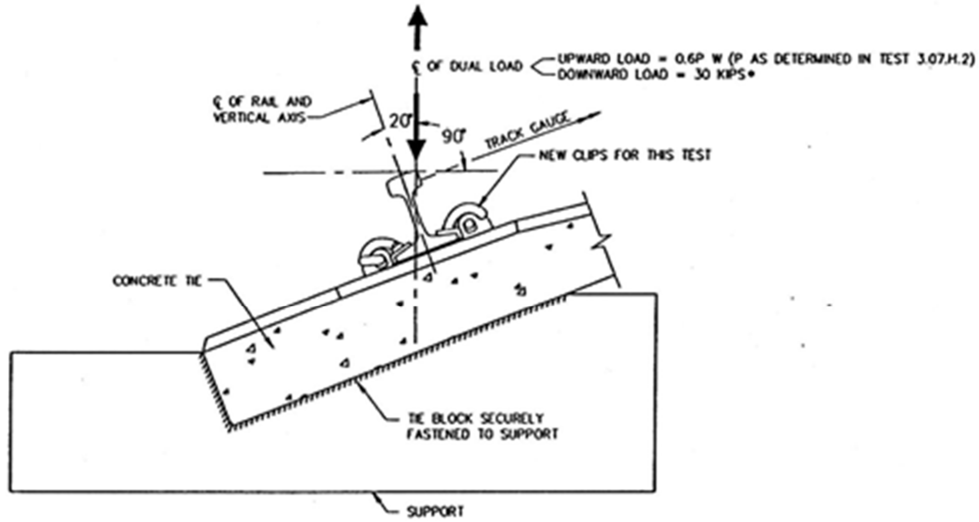
THE MINIMUM FOR 500 VOLTS DC SHALL BE 0.4 MEGOHM (WET). THE MINIMUM IMPEDANCE FOR ANY FREQUENCY BETWEEN 20 HERTZ AND 12 KILOHERTZ WITH 50 VOLTS AC APPLIED SHALL BE 10,000 OHMS.

FIGURE 6

3.08.F RAIL FASTENING REPEATED LOAD TEST

3.08.F.1 A CONCRETE TIE WITH A NEW COMPLETE FASTENING ASSEMBLY AND A 19 INCH SECTION OF NEW RAIL, WITH MILL SCALE REMOVED, SHALL BE INSTALLED AT THE RAIL SEAT.

THE CONCRETE TIE WITH FASTENING SHALL BE SUPPORTED IN A HYDRAULIC TESTING MACHINE AS SHOWN BELOW WITH UPWARD AND DOWNWARD LOADING SO ARRANGED THAT THE LOAD IS APPLIED AT AN ANGLE OF 20° TO THE VERTICAL AXIS OF THE RAIL.



3.08.F.2 A DUAL TEST LOAD OF 30* KIPS AND 0.6P SHALL BE APPLIED ALTERNATING DOWNWARD AND UPWARD RESPECTIVELY, AT A RATE NOT EXCEEDING 300 CYCLES PER MINUTE. THE RAIL SHALL BE FREE TO ROTATE UNDER THE APPLIED LOADS. ONE CYCLE SHALL CONSIST OF BOTH A DOWNWARD AND UPWARD LOAD. TEST SHALL CONSIST OF 3,000,000 CYCLES.

THIS REPEATED LOAD TEST MAY GENERATE HEAT IN ELASTOMERIC RAIL SEAT PADS. PAD TEPERATURE SHALL NOT BE ALLOWED TO EXCEED 120° F. HEAT BUILD-UP SHALL BE CONTROLLED BY REDUCING THE RATE OF LOAD APPLICATION OR BY PROVIDING PERIODS OF REST TO ALLOW COOLING OF THE PAD TO TAKE PLACE.

3.08.F.3 ACCEPTANCE CRITERIA

IF RUPTURE FAILURE OF ANY COMPONENT OF THE FASTENING SYSTEM DOES NOT OCCUR, THE REQUIREMENT OF THE TEST WILL HAVE BEEN MET.

• IF SPRINGS ARE USED TO GENERATE UPWARD LOAD THE DOWNWARD LOAD SHALL BE 30 KIPS PLUS 0.6P. IF A DOUBLE ACTING HYDRAULIC RAM IS USED TO GENERATE BOTH UPWARD AND DOWNWARD LOAD, USE LOADS AS SPECIFIED.

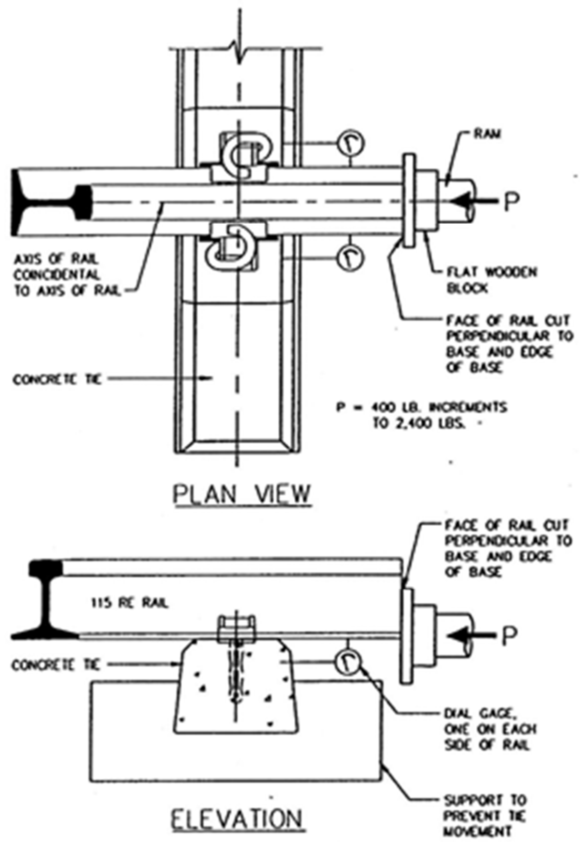
FIGURE 7

3.08.G RAIL FASTENING LONGITUDINAL RESTRAINT TEST

3.08.G.1 SUPPORT A SUCCESSFUL CONCRETE TIE WITH FASTENING ASSEMBLY FROM TEST 3.08.F – REPEATED LOAD TEST (WITHOUT DISTURBING THE RAIL FASTENING ASSEMBLY) IN A HYDRAULIC TESTING MACHINE AS SHOWN ON THE RIGHT, WITH TWO DIAL GAGES, AND LOADING POINT SO ARRANGED THAT THE LOAD IS APPLIED LONGITUDINAL TO THE BASE AND CENTERLINE AXIS OF THE RAIL.

3.08.G.2 THE TEST LOADING SHALL BE APPLIED IN INCREMENTS OF 400 POUNDS. LONGITUDINAL RAIL DISPLACEMENT READINGS SHALL BE RECORDED AT EACH INCREMENT. RECORDED READINGS TO 0.001 INCH SHALL BE THE AVERAGE OF THE TWO GAGES.

3.08.G.3 THE TEST LOAD SHALL BE INCREASED INCREMENTALLY TO A LOAD OF 2.4 KIPS AND HELD FOR NOT LESS THAN 15 MINUTES, UNLESS RAIL MOVEMENT EXCEEDS 0.125 INCHES AT A LESSER LOADING.



3.08.G.4 ACCEPTANCE CRITERIA

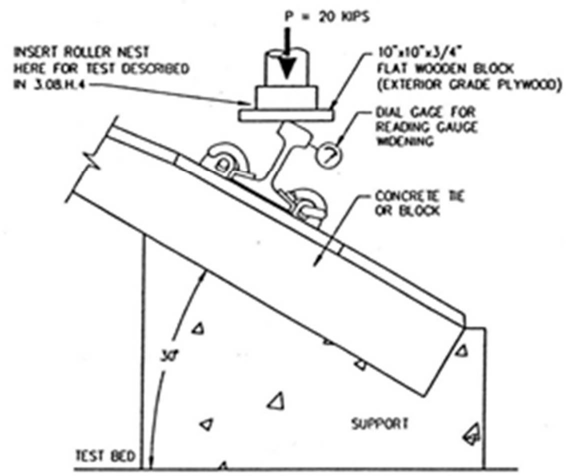
IF THE RAIL MOVEMENT IS LESS THAN 0.125 INCHES DURING THIS TEST PERIOD THE REQUIREMENT OF THE TEST WILL HAVE BEEN MET. THE FASTENING ASSEMBLY SHALL MEET THE REQUIREMENTS OF THIS TEST WITH LOADING IN EITHER DIRECTION.

FIGURE 8

3.08.H RAIL FASTENING LATERAL RESTRAINT TEST

3.08.H.1 A CONCRETE TIE WITH A NEW COMPLETE FASTENING ASSEMBLY AND A 19 INCH SECTION OF NEW RAIL, WITH MILL SCALE REMOVED, SHALL BE INSTALLED AT THE RAIL SEAT.

THE CONCRETE TIE WITH FASTENING SHALL BE SUPPORTED IN A HYDRAULIC TESTING MACHINE AS SHOWN BELOW WITH THE LOADING HEAD FIXED AGAINST TRANSLATION AND ROTATION.



3.08.H.2 RESTRAINED LATERAL LOAD TEST

A PRELOAD OF 10 KIPS 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 GAGE INDICATORS THAT MEASURE RAIL TRANSLATION. LOAD SHALL BE APPLIED AT A RATE NOT TO EXCEED 5 KIPS PER MINUTE UNTIL EITHER 20 KIPS HAVE BEEN APPLIED OR THE RAIL BASE HAS TRANSLATED 1/8 INCH, WHICHEVER OCCURS FIRST.

3.08.H.3 ACCEPTANCE CRITERIA, RESTRAINED LATERAL LOAD TEST

IF THE FASTENING SYSTEM AND THE TIE SUPPORTS THE 20 KIP LOAD WITH 1/8 INCH OR LESS OF RAIL TRANSLATION THE REQUIREMENT OF THE TEST WILL HAVE BEEN MET. FAILURE OF ANY COMPONENT OF THE FASTENING SYSTEM OR TIE SHALL CONSTITUTE FAILURE OF THE TEST.

3.08.H.4 UNRESTRAINED LATERAL LOAD TEST

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 GAGE INDICATORS, THAT MEASURE GAUGE WIDENING AND RAIL TRANSLATION, A LOAD OF 10 KIPS SHALL BE APPLIED AT A RATE NOT TO EXCEED 5 KIPS PER MINUTE.

3.08.H.5 ACCEPTANCE CRITERIA, UNRESTRAINED LATERAL LOAD TEST

RAIL ROTATION, DEFINED AS GAUGE WIDENING LESS RAIL TRANSLATION, GREATER THAN 1/4 INCH SHALL CONSTITUTE FAILURE OF THIS TEST.

FIGURE 9

END OF SECTION 34 11 33

SECTION 34 11 34

TIMBER SWITCH TIES

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for furnishing timber switch ties for ballasted special trackwork.

B. Related Sections:

1. 34 11 23 Special Trackwork.
2. 34 11 28 Special Trackwork Construction.

1.02 REFERENCED STANDARDS

A. American Railway Engineering and Maintenance-of-Way Association (AREMA):

1. Manual of Railway Engineering.

B. American Wood Preservers' Association (AWPA):

1. P1/P13 Standard Creosote for Preservative.

C. West Coast Lumber Inspection Bureau (WCLB):

1. No. 17 Standard Grading Rules.

1.03 SUBMITTALS

A. AREMA: American Railway Engineering and Maintenance-of-Way Association (AREMA).

B. AREMA Manual: Current edition of the AREMA Manual for Railway Engineering (Fixed Properties), Chapter 3, "Ties and Wood Preservation."

C. WCLB: West Coast Lumber Inspection Bureau.

D. AWPA: American Wood-Preservers' Association.

E. Tie, Ties, or Timber Ties: When the term Tie, Ties, or Timber Ties is used in these technical specifications, the term shall apply to cross ties and to switch ties.

1.04 SUBMITTALS

A. The Contractor shall make all submittals in accordance with the requirements of Special Conditions SC-6 and SC-51 and as specified herein.

B. Submit a schedule of machining, treatment and delivery of timber ties, 25 calendar days after the Notice to Proceed.

C. Submit list of preservatives for approval.

D. Submit completed treatment records form specified in AREMA Manual, Chapter 3, Part 6.4, "Preservatives," 7 calendar days before shipment of ties.

E. Submit certificates of compliance for preservative treatment, ascertaining conformance with the approved preservative within 7 calendar days after completion of testing.

F. Submit Inspection Certificate, complying with WCLB No. 17, 25 working days before application of preservative treatment.

G. Submit test results and certificates of compliance for preservatives used in treatment of switch ties no later than 25 working days before treatment.

1.05 INSPECTIONS

A. Advise VTA when ties are ready for inspection as specified in Article 2.01K, herein.

1.06 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 – PRODUCTS

2.01 SWITCH TIES

A. Switch ties shall be new, hardwood ties meeting the requirements of the AREMA Manual. Pacific Coast region Douglas Fir ties shall conform to WCLB No. 17, Paragraph 192-b, No. 1 - Railroad Ties.

B. Switch ties shall conform to the following:

1. Sawed straight and cut square at ends. Top and bottom of each tie shall be parallel, and the sides shall be parallel. Criteria on straightness and parallel properties contained in the AREMA Manual, Chapter 3, Part 2, Paragraph 2.1.4.11, shall apply.

2. Switch ties shall meet the requirements of the AREMA Manual, Chapter 3, Part 2, Paragraphs 2.1.4.3 through 2.1.4.10.

C. Switch ties shall be handled, air seasoned or dried, transported, and stored in conformance with the requirements of the AREMA Manual, Chapter 3, Part 5, The Handling of Ties from the Tree into the Track.

D. Switch ties shall have the following dimensions:

1. 7 inch x 9 inch in cross section.

2. Length as indicated in the turnout manufacturer's shop drawings.

E. Preservative applied to switch ties shall conform to the AWPA P1/P13.

F. Switch ties shall be machined as specified herein and in accordance with the AREMA Manual, Chapter 3, Section 1.5. Machining shall be performed before application of preservative treatment.

1. Switch ties shall be sawed top, bottom, and sides.

2. Switch ties shall be incised before treatment in accordance with AREMA Manual, Chapter 3, Paragraph 1.4.1.

3. Switch ties shall be branded in accordance with AREMA Manual, Section 1.4.5. Each tie shall identify the following: plant symbol, year of manufacture, and VTA.

G. Contractor shall not treat any switch ties until:

1. Moisture content is 20 percent or less.

2. Ties have been inspected and released for treatment by VTA.

3. Preservatives, which will be used for treating have been tested by Contractor and approved by VTA.

4. Ten working days prior notification of treatment operations has been issued by Contractor and received by VTA.

H. Procedure:

1. Switch ties shall be conditioned and treated in accordance with AWPA P1/P13, Standard C6, to a final retention of 8 lb/ft^3.

2. Treatment provisions of the AWPA P1/P13 shall be modified as follows: Treatment shall provide 1/2 in. minimum and 3/4 in. average penetration.

3. During treatment operations, the treatment records specified in the AREMA Manual, Part 6, shall be filled out.

I. Approved timber switch ties shall be branded on the line end as specified herein by an approved method that will prevent obliteration by treatment process or storage.

1. VTA shall have the right at any time to test the preservative to be used in treating switch ties. Samples may be taken from any container in which the preservative is stored or used.

2. Upon approval by VTA, treated switch ties will be stamped for quality control by VTA at its option indicating compliance with these technical specifications.

3. VTA will clear approved material for loading before shipment.

J. Switch ties shall be subject to inspection by Contractor's representative.

1. Contractor shall provide suitable facilities, equipment and assistance necessary for the safety and convenience to make inspections.

2. Contractor shall advise their representative when switch ties are ready for inspection, 25 working days before treatment, either at the sawmill or at the treatment plant, or both.

3. Contractor shall advise their representative when treated switch ties are ready for inspection 25 working days before loading, at the treatment plant.

4. Switch ties that do not meet specified requirements shall be removed and replaced by Contractor at no expense to VTA.

K. Except as modified herein, switch ties shall be handled, shipped, and stored in accordance with the AREMA Manual, Chapter 3, Part 5. To minimize damage to switch ties they shall not be handled unnecessarily. Only lifting devices which will not cause damage to the switch tie shall be used.

1. Switch ties shall be bundled for shipment by Contractor in quantities of 15 to 25 ties per bundle. Contractor shall use at least 2 bands per bundle. These bands shall be such that they will satisfactorily hold the ties together through the transportation, handling, stacking and storage phases without damage to ties. Smaller quantity bundles will be accepted only to complete an order.

2. Switch ties shall be stacked at the designated locations in accordance with AREMA Manual, Chapter 3, Part 5. Switch ties shall be stacked a minimum of 6 in. above the ground with a minimum of 3 in. separating each subsequent bundle. Contractor shall provide materials, labor, and equipment required for unloading and stacking ties in a safe manner without causing damage. Banding equipment shall accompany any delivery; bands damaged during shipping and unloading shall be immediately replaced at the delivery site.

3. Switch ties shall not be stacked more than 3 bundles high.

2.02 ANTI-SPLITTING DEVICES

A. Switch ties shall be equipped with anti-splitting devices regardless of whether or not the wood has shown any tendency to split. Products used shall conform to AREMA Chapter 3, Part 1, Section 1.6, "Specifications for Devices to Control the Splitting of Wood Ties."

B. Switch ties shall be equipped on each end with steel multi-nail plates.

C. Multi-nail plates shall be applied in accordance with AREMA Chapter 3, Part 1, Section 1.6, "Specifications for Devices to Control the Splitting of Wood Ties."

PART 3 – EXECUTION

3.01 SWITCH TIES

A. Timber switch ties shall be installed with special trackwork as specified in Section 34 11 28, "Special Trackwork Construction."

END OF SECTION 34 11 34

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SECTION 34 11 36

DIRECT FIXATION FASTENERS

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for designing, manufacturing, inspecting, testing, shipping, delivering, unloading, and stockpiling of direct fixation rail fasteners (DFF) for direct fixation aerial trackwork with continuous welded rail.

1.02 PRINCIPLE ITEMS INCLUDED

A. Materials:

1. Fastener body.
2. Rail clip assemblies.
3. Anchor assemblies.
4. Height adjustment shim plates.

B. Service:

1. Program management.
2. Design.
3. Qualification testing.
4. Production quality control testing.
5. System support.
6. Delivery, unloading, and stacking of furnished materials to the specified site(s) directed by the Engineer.

C. Installation and Maintenance Manual

1.03 REFERENCED STANDARDS

A. Reference Standards: Perform Work in accordance with the following reference standards for manufacturing of components and testing procedures.

1. American National Standards Institute (ANSI):
   a. ANSI B1.1: Unified Inch Screw Threads (UN and UNR Thread Form).
   b. ANSI B1.3: Screw Thread Gauging Systems for Dimensional Acceptability

- Inch and Metric Screw Threads (UN, UNR, UNJ, M, and MJ).

c. ANSI B18.2.1: Square and Hex Bolts and Screws (Inch Series).

d. ANSI B 18.21.1: Lock Washers (Inch Series).

e. ANSIB18.22.1: Plain Washers (Reaffirmation and Redesignation of ASA B27.2-1965.

2. American Railway Engineering Association (AREA): Manual for Railway Engineering (Fixed Properties), Volume 1, Chapter 4, Rail.

3. American Society for Testing and Materials (ASTM):

a. ASTM A36: Structural Steel.

b. ASTM A123: Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

c. ASTM A167: Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.

d. ASTM A536: Ductile Iron Castings.

e. ASTM A615: Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.

f. ASTM A775: Epoxy-Coated Reinforcing Steel Bars.

g. ASTM B117: Salt Spray (Fog) Testing.

h. ASTM B633: Electrodeposited Coatings of Zinc on Iron and Steel.

i. ASTM C39: Compressive Strength of Cylindrical Concrete Specimens.

j. ASTM C778: Standard Sand.

k. ASTM C882: Bond Strength of Epoxy-Resin Systems used with Concrete by Slant Shear.

l. ASTM D257: D-C Resistance or Conductance of Insulating Materials.

m. ASTM D395: Rubber Property - Compression Set.

n. ASTM D412: Vulcanized Rubber and Thermoplastic Elastomers - Tension.

o. ASTM D429: Rubber Property - Adhesion to Rigid Substrates.

p. ASTM D471: Rubber Property-Effect of Liquids.

q. ASTM D518: Rubber Deterioration - Surface Cracking.

r. ASTM D570: Water Absorption of Plastics.

s. ASTM D573: Rubber-Deterioration in an Air Oven.

t. ASTM D638: Tensile Properties of Plastics.

u. ASTM D695: Compressive Properties of Rigid Plastics.

v. ASTM D732: Shear Strength of Plastics by Punch Tool

w. ASTM D790: Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

x. ASTM Dl 149: Rubber Deterioration-Surface Ozone Cracking in a Chamber.

y. ASTM D1229: Rubber Property - Compression Set at Low Temperatures.

z. ASTM D1566: Standard Terminology Relating to Rubber.

aa. ASTM D2240: Rubber Property - Durometer Hardness.

bb. ASTME10: Brinell Hardness of Metallic Materials.

cc. ASTME23: Notched Bar Impact Testing of Metallic Materials.

dd. ASTME162: Surface Flammability of Materials Using a Radiant Heat Energy Source.

ee. ASTM E329: Standard Specification for Agencies Engaged in Construction Inspection and/or Testing

4. National Fire Protection Association (NFPA):

a. 258 Determining Smoke Generation of Solid Materials

5. Rubber Manufacturers Association, Inc. (RMA): Rubber Handbook.

6. Society of Automotive Engineers (SAE):

a. SAE J429: Mechanical and Material Requirements for Externally Threaded Fasteners.

b. SAE J434: Automotive Ductile (Nodular) Iron Castings.

c. SAE J995: Mechanical and Material Requirements for Steel Nuts.

7. Steel Structures Painting Council (SSPC) VIS 1: Visual Standard for Abrasive Blast Cleaned Steel (Standard Reference Photographs)

1.04 ABBREVIATIONS AND DEFINITIONS

A. Abbreviations: The abbreviations used in these Specifications are defined in the test as follows:

1. AC Alternating current
2. ANSI American National Standards Institute
3. AREA American Railway Engineering Association
4. ASTM American Society for Testing and Materials
5. ºC Degrees Celsius
6. cm Centimeters
7. Btu British thermal unit
8. DC Direct current
9. ºF Degrees Fahrenheit
10. ft Feet
11. hr Hour
12. in Inch
13. lbs Pounds
14. m Meter
15. max Maximum
16. mg Milligram
17. min Minimum
18. mph Miles per hour
19. NFPA National Fire Protection Association
20. pH Potential of hydrogen
21. ppm Parts per million
22. QA Quality Assurance
23. RMA Rubber Manufacturers Association
24. RTP Rail Transit Project
25. SAE Society of Automotive Engineers
26. SSPC Steel Structures Painting Council
27. UNC Unified Inch (Course) Screw Threads

B. Definitions: Terms in these Specifications that are not in general usage or that have specific connotations are as defined below:

1. Others. An entity that provides goods and/or services related to the Work exclusive of the requirements of the Contract.

2. Production Lots. A quantity of manufactured and completed direct fixation rail fasteners equal to the number of fasteners required on each delivery date, as listed in the fastener delivery schedule.

3. Provide. Work that shall be performed by the Contractor; synonymous with furnish and install.

4. Qualification Test. A test performed prior to production to verify that the components proposed meet the requirements of these specifications.

5. Working Days. Days of the week which include Monday, Tuesday, Wednesday, Thursday, and Friday, except those days that fall on legal Federal, State of California, or Santa Clara County holidays.

6. Bare Surface. A metallic surface on the fastener that is not covered with at least a 1/8 inch thickness of bonded elastomeric material.

1.05 DESIGN CRITERIA

A. Fastener Assembly: Fastener assemblies required by these Specifications will be for the installation of 115RE running rail for exclusive LRV use. Fastener assemblies required for installation for restraining rail will be installed with 115RE running rail. Tee rail section, LRV characteristics and axle loadings of rail are shown on VTA Design Manual. All fasteners supplied in response to this Specification shall be of the same design and utilize only the same components. The fastener assembly shall consist of the components specified below.

1. A fastener body which has a metal top element for support of the running rail and securing of rail clips and an elastomeric element between the rail plate and the concrete surface or adjustment shim plates that provides isolation of the rail plate. Alternate designs using a metal top element, metal base element and an elastomeric element between them which is vulcanized bonded to both metal plates during the elastomer vulcanization process, may be proposed and may be acceptable.

2. Two resilient steel spring type rail clips, one on each side of the rail, for securing the running rail to the metal top element of the fastener body.

3. Two anchor assemblies, including female-type anchor inserts for embedment in the concrete trackbed, anchor bolts for securing the fastener to the concrete trackbed, and an adjustment feature to enable the fastener to be laterally repositioned in a direction perpendicular to the rail.

4. Metal shim plates used for height adjustment, and placed between the fastener base and the concrete trackbed.

5. Direct fixation fastener assemblies shall be similar in design and compatible with the direct fixation fastener system presently installed at other location on VTA's LRT system.

6. All direct fixation track shall be constructed with rail cant of 1:40 toward the centerline of the track. The direct fixation fasteners shall be supplied with this 1:40 cant built into the fastener base.

B. Fastener Functions: The fastener shall be designed to perform the functions specified below. The expected service life shall be a minimum of 25 years.

1. Secure the running rail to concrete trackbed in direct fixation track.

2. Provide vertical, lateral, and rotational stability to the rail.

3. Restrain the rail from movement in the longitudinal direction.

4. Attenuate vibration generated by moving wheels on the rail.

5. Electrically insulate the running rail from the concrete trackbed.

C. Design Properties of Fastener Assembly: The complete fastener assembly shall have the overall configuration and performance functions specified below.

1. Dimensions:

a. When completely assembled with clips and anchors, all parts of the fastener above the concrete trackbed shall stay within a design envelope of 14 to 16 inches measured horizontally perpendicular to the rail, and not wider than 10 inches measured horizontally parallel to the rail.

b. The height of the fastener body, measured vertically from the base of the fastener body to the base of rail at the rail centerline and excluding shims, shall not be greater than 1-7/8 inches.

c. No portion of the completely assembled fastener, including rail clips and anchor bolts, shall extend any higher than 4 inches measured vertically from the base of rail at the rail centerline.

d. The design spacing of anchor assemblies and other dimensions shall be as indicated in Figure 1.

e. When installed, no part of the anchor insert shall be deeper than 5 1/4 inches from the concrete trackbed surface or further than 1-1/4 inches horizontally from the centerline of insert both parallel to and perpendicular to the rail.

f. The diameter of the fastener body and anchor assembly component holes through which the anchor bolt passes shall not be less than 0.895 inch nor more than 0.938 inch.

g. With the rail clips removed from the otherwise assembled fastener, no portion of the fastener shall extend any higher than 1-1/2 inches above the base of rail, as measured vertically from the base of rail at the rail centerline.

2. Overall Design Guidelines:

a. Design the fastener to have as few components as economically and technically feasible to facilitate assembling, disassembling, and maintenance at track sites.

b. Except for the anchor insert, the fastener shall permit quick installation and replacement at the track site of the entire fastener, or its components, by one person using standard hand tools.

c. The fastener shall be designed to allow installation and removal of the fastener or its components in all positions of lateral adjustment.

d. Welding shall not be used in the fabrication or assembly of any fastener component.

3. Rail Securing Configuration:

a. The metal top element of the fastener body shall have a flat rail-bearing seat in the center of the fastener that supports the rail directly without intermediate pads or shim plates and shall be shaped to tilt the rail inward to the gauge side at a 1:40 cant. Shoulders to help hold the rail to line and gauge shall be provided cast with the metal top and shall be set parallel on both sides of the rail base.

b. The rail shall be held to the metal top element by two steel spring clips, securing both the gauge and field sides of the rail base. The clips shall be held by a clip with the metal top element of the fastener in a manner that does not allow lateral rail adjustment on the metal top element. The clips shall be one-piece, threadless, and designed to be easily removable by maintenance personnel with standard hand tools but not able to vibrate loose under vehicle operating conditions.

c. Clip removal shall not require loosening of anchor bolts and rail shall be removable by raising the rail vertically until it is completely free of the fastener without disturbing the horizontal or vertical alignment of the fastener.

d. Longitudinal rail restraint properties of the fastener shall be identical in both longitudinal directions.

e. Lateral rail restraint properties of the fastener shall be identical in both lateral directions.

4. Fastener Anchoring Configuration:

a. The base of the fastener shall be horizontal when the fastener is placed on tangent, un-superelevated track.

b. The fastener body shall be secured to the concrete trackbed with two 7/8 inch diameter anchor bolts, one on each side of the rail.

c. The anchor bolts shall be threaded into female-type anchor inserts embedded in the concrete trackbed perpendicular to the fastener base.

d. The fastener design shall provide a means of adjusting the rail laterally within a range of plus or minus 1/2 inch in increments of 1/8 inch or less. The adjustment feature shall be integral with the anchor assemblies. Lateral or longitudinal stability of the rail shall not be reduced in adjusted position. 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 a component, and does not require the movement of an anchor bolt laterally.

e. If serrations are used for lateral rail adjustment, not less than three interlocking serrations shall be engaged in any position of lateral adjustment.

5. Vibration Attenuation:

a. The rail fastener shall be designed to attenuate vibration transmitted by vehicle operation on the rail to the concrete trackbed.

b. The elastomer used to achieve the vibration attenuation, in addition to electrical isolation, shall provide flat, parallel surfaces and full bearing at least equal to the footprint of the metal top element. Adequate means shall be provided to ensure the elastomer pad will remain centered under the metal top element under all conditions of service and adjustment and for the life of the product.

c. The attenuation performance of the fastener shall not be compromised in any position of lateral adjustment.

d. Precompression of the elastomer by the anchor assembly when the anchor bolts are tightened to the design installation torque shall not be permitted except by written permission from the VTA upon submittal of documents which show that.

1) Torquing the anchor bolt to proper torque shall not limit the vibration reduction performance of the elastomer and shall still meet minimum electrical resistance and impedance requirements for electrical insulation of the fastener.

2) The elastomer shall not contribute toward accelerated vibration-loosening of anchor bolts.

3) The design shall not cause or contribute to premature breakdown of elastomer performance, nor cause or contribute to premature reduction of electrical insulating qualities for the fastener, over the life of the fastener.

4) The anchor assembly shall not require additional separate elastomer parts that require assembly during installation.

6. Electrical Insulation Qualities:

a. Electrical insulation of the running rail from the concrete trackbed is essential to contain the returning traction power current within the running rails. Stray current resulting from poor electrical insulation causes cumulative damage to metallic components of transit structures, facilities outside the transit structures, and fastener components, leading to considerable reduction in their service life. Experience indicates that many failures of track to meet electrical insulation requirements are directly related to electrically conductive moisture and dirt trapped in crevices or depressions on the fastener or on various component surfaces.

b. Recesses in the fastener shall be free-draining in all positions of lateral adjustment and at maximum track superelevation of six inches. Fastener surfaces (including elastomer) shall be resistant to conductive oil and dirt buildup and facilitate effective periodic cleaning by track maintenance equipment and personnel.

c. The fastener design shall provide an electrical leakage distance path along elastomer-covered surfaces of not less than 3/4 inch, under all load and adjustment conditions. This leakage path shall be measured from any bare surface on the grounded portion of the fastener including anchor assemblies to any bare surface on the metallic portion of the fastener in direct contact with rail by the most direct path that does not pass through elastomeric insulating material. The leakage distance shall exclude recesses and other geometric configurations which could collect and hold moisture, dust, and other materials which could create a conductive path to ground.

D. Design Basis:

1. Installation: The fastener shall be designed to meet the requirements described in Article 1.04B. Installation shall be as indicated in Section 34 11 27, “Direct Fixation Track Construction.”

2. Rail: The fastener shall be designed for use with 115RE rail as shown on the Plans and as specified by AREMA, Chapter 4. Standard gauge shall be 4 feet 8 1/2 inches.

3. Adjustment: For height adjustment during installation, one or two shim plates of 1/8 inch or 3/8 inch thickness, but not exceeding 1/2 inch total thickness, may be placed under the fastener elastomer pad and on the concrete trackbed.

4. Trackbed: Fasteners will be placed upon a reinforced concrete trackbed. The concrete will have a 28-day compressive strength of 4,000 psi. The female-type anchor inserts will be either cast into the concrete during the pour or they may be installed in cored holes after concrete placement, spaced to match the anchor design of each fastener and fastener spacing along the rail of 30 inches. They will be set so that the top face of the insert is flush with the top surface of the concrete. Installation will require 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 described in Article 1.13. Bonding agents for application to base of fastener, to shims, or to concrete surface during installation will not be permitted.

5. Ambient Conditions: The fasteners shall be designed to withstand the following ambient conditions:

Air Temperature Range (C)	0-46
Relative Humidity Range (%)	10-100
Rainfall (Maximum inch/hour)	4
Wind (steady state/gusts, maximum mph)	30/60
Hail/Snow	Trace
Fog	Heavy
Air Quality:	
Particulate (Average mg/m^3)	0.248
O_3 (max-ppm)	0.35
NOx (max-ppm)	0.44
SOx (max-ppm)	0.037
CO (max-ppm)	29
Chloride Content (mg/m^3)	13.9
Moisture Acidity (pH)	4.41

Solar Radiation (max-Btu/hr/ft^2) 275

1.06 MATERIAL IDENTIFICATION

A. Records: Material identification shall be as specified below. At the time the completed fasteners are shipped, a copy of the production lot records shall be shipped with them and another copy shall be submitted separately to the VTA.

B. Part Numbers: Part numbers shall be assigned to fastener components and to finished assemblies. Part numbers shall be used on related drawings, correspondence, documents, and on shipping lists included with delivered fasteners. Part numbers shall identify specific items in specific configurations. All parts identified by the same part number shall have the same physical dimensions, material composition, performance characteristics, and durability. If parts are altered in any fashion during testing or at any other time, separate part numbers shall be assigned to the superseding parts and duly indicated on the fastener shop drawings and as-built drawings for resubmittal to the VTA.

C. Identification Marking: A lot and fastener numbering system shall be developed for marking each fastener and submitted to the VTA for approval. The lot number, a daily production identification number, and the Contractor's name or trademark shall be permanently and clearly stamped or molded on the top of each fastener so that they are readily visible when the complete assembly is in the installed position. In addition, the letter "G" shall be permanently marked in the same manner on the gauge side of the fastener, to clearly indicate the correct orientation for installation in track.

1.07 SUBMITTALS

A. The Contractor shall make all submittals in accordance with the requirements of Special Conditions SC-6 and SC-51 and as specified herein.

B. All submittals, shop drawings, correspondence, documents and shipping lists associated with the production and delivery of the products and any other components of this Specification Section shall be in dual convention indicating for each dimension, both English units and exact metric equivalents.

C. Design Drawings: Contractor shall submit design drawings for approval as specified herein. The design drawings required shall include the following:

1. Fastener Shop Drawings: Fastener shop drawings showing design details of each fastener component separately before assembly, the complete fastener assembly, and the shuns. These drawings shall be drawn to scale and shall include all necessary dimensions, tolerances and material designations for manufacturing the components, as well as a table listing all components shown by name and by part number.

2. Test Apparatus Working Drawings: The Contractor shall include with the Test Procedures for each test, working drawings showing details of the concrete test blocks and testing equipment, and the set-up for each test required in these specifications. Pertinent testing drawings included in standard specifications referenced herein may be referenced in the report in lieu of actual drawings.

3. Fastener Record Drawings: Prior to or concurrent with acceptance of the last product, all VTA approved changes shall be incorporated by the Contractor into the fastener Shop Drawings. Copies of the updated drawings shall be submitted to the VTA to serve as the

final (record) Configuration Drawings.

D. Data Submittals: The Contractor shall submit design data, qualification test data, and production quality control test data to the VTA for approval.

E. Submit qualification certification of the testing laboratory and test documentation as specified in Article 1.08 B.

F. Installation and Maintenance Manual:

1. Prepare and submit a manual for the installation and maintenance of the fasteners. The manual will be used to help ensure the accurate and secure placement of the fasteners during track construction under another contract and as a reference by track maintenance personnel of the VTA.

2. Progressive Submittals:

    a. Submit the proposed format for the Installation and Maintenance Manual, including a table of contents, not less than 90 days before the first delivery of fasteners.

    b. Submit the completed Installation and Maintenance Manual in final form together with the first delivery of fasteners.

    c. Submit six copies of the Installation and Maintenance Manual within 60 calendar days after the first delivery of fasteners. This submittal shall include any revisions required by the VTA as a result of the VTA's review.

    d. Furnish one copy of letter indicating that suppliers have been notified to provide updated installation and maintenance data, service bulletins, and other information pertinent to the fasteners, as it becomes available.

3. Format:

    a. Paper: White bond, at least 20 pound weight, 8-1/2 inches by 11 inches in size.

    b. Text: Printed, typewritten, or word-processed.

    c. Printed Data: Manufacturer's catalog cuts, brochures, and operation and maintenance data. Clear reproductions thereof will be acceptable.

    d. Drawings: 8-1/2 inches by 11 inches, preferably bound in with text. Larger drawings are acceptable, provided they are folded to fit into a pocket inside the rear cover of the manual. Reinforce edges of large drawings.

    e. Prints of Drawings: Black on white, sharp in detail and suitable for making reproductions.

    f. Flysheets: Separate each portion of the manual with colored, neatly prepared flysheets briefly describing contents of the ensuing portion.

    g. Covers: Provide 40 to 50 mil thick, clear plastic, front and back covers for each manual. Include the following information on the cover and on inside cover sheet:

1) INSTALLATION AND MAINTENANCE MANUAL

2) DIRECT FIXATION RAIL FASTENERS

3) (NAME OF CONTRACTOR)

4) (ADDRESS)

5) (CITY, STATE)

6) (CONTRACTOR'S TELEPHONE NUMBER)

7) (GENERAL SUBJECTS OF THIS MANUAL)

8) Signed & Sealed by a Professional Engineer (California Registered)

9) Acceptance Date

h. Bindings: Conceal the binding mechanism inside the Manual; three-ring binders will be acceptable. Binding is subject to approval by VTA.

4. Manual Content:

a. Assembly Installation and Maintenance Manual using manufacturer's latest standard commercial data.

b. A table of contents, including titles and page numbers of main sections on installation and maintenance as well as subsections.

c. An index including a list of parts and processes, in alphabetical order and page number where each subject is found in the manual.

d. Names, addresses and telephone numbers of Contractor, parts suppliers and applicable agencies and associations.

e. Names, addresses and telephone numbers of manufacturers' nearest service representatives.

f. Names, addresses, and telephone numbers of local parts vendor and service agency.

g. Copies of guarantees and warranties issued to, and executed in the name of, the VTA.

h. Expected date after beginning of service mat the VTA should expect to perform fastener maintenance.

i. Description of fastener assembly and all component parts. Includes shop drawings and specifications for correct type of height adjustment shims, to be provided by Others.

j. Pre-installation check or inspection list.

k. Procedures for preparation and repair of concrete trackbed on which the fasteners are to be placed, including preparation of concrete for placement of anchor inserts.

l. Anchor insert care and installation procedures.

m. Design dimensions, material specifications, placement restrictions, and installation procedures for height adjustment shims.

n. Installation procedures for fastener bodies, rail clips, and anchor assemblies.

o. Lateral adjustment method.

p. Anchor bolt torquing requirements and retorquing limitations and procedures.

q. Installation tools required and names and addresses of tool suppliers.

r. Requirements and restrictions for proper placement of rail on the fasteners.

s. Special requirements for fastener installation at rail joints, including specifications and installation methods for special rail clips.

t. Accepted test data.

u. Maintenance schedules and procedures.

v. One copy of each approved Shop Drawing. If drawings are larger than 8-1/2 inches x 11 inches, they shall be reduced to a page height of 11 inches and folded, if necessary, to an 8-1/2 inch page width.

w. A compact disk or USB drive with all shop drawings in PDF format downloaded.

x. Manufacturer's parts lists with catalog names, numbers, and illustrations.

y. An exploded view of each piece of the fastener assembly, including height adjustment shims, with part designations.

z. List of manufacturers' recommended spare parts, prices, and quantities for two years of operation.

aa. Scale and corrosion control procedures.

bb. Dismantling and reassembly Instructions.

1.08 QUALITY ASSURANCE/CONTROL

A. Tolerances:

1. Manufacturing Tolerances for the Fastener.

a. Length and Width: Plus or minus 1/16 inch.

b. Height: Plus or minus 1/32 inch.

c. Squareness: All angles shall be within plus or minus one degree.

d. Centering of Holes: Plus or minus 1/32 inch.

e. Diameter of Holes: Plus or minus 1/32 inch.

f. Durometer Shore A: Plus or minus five.

g. Serration Depth: Plus or minus 1/64 inch.

h. Serration Spacing: Plus or minus 1/64 inch.

i. Width Between Shoulders at Rail Base: Plus 1/16 inch or minus zero inch.

j. Cant of Top Plate Supporting Rail: 1:35 to 1:45.

2. Forming Tolerances for the Concrete Test Block Used for Fastener Tests:

a. Concrete Surface Flatness: Maximum 1/16 inch gap between 16 inch straight edge and concrete surface all around.

b. Elevation of Top Face of Anchor Insert Embedded in Concrete: Zero inch above or 1/16 inch below top surface of concrete.

c. Voids in Bearing Surface of Concrete: No void shall be greater than 1/2 inch and total area of voids shall be less than ten percent of total fastener bearing area.

3. Dimensions Affecting the Shape of the Elastomer: Shall be determined by the Contractor so that the complete fastener conforms to the physical requirements and acceptance criteria for fastener tests.

B. Testing: Testing shall be performed to demonstrate that fasteners and fastener components meet the requirements of these specifications. Two series of tests are required: qualification tests and production quality control tests. The VTA shall be notified in writing not less than 14 days in advance of dates scheduled for any tests. The VTA retains the right to witness the tests and no tests shall be conducted until authorized by the VTA.

1. Qualification Tests: Tests performed prior to production to verify that the proposed fasteners and fastener components meet the requirements of these specifications.

2. Production Quality Control Tests: Tests performed during production to verify that the manufactured fasteners meet the requirements of these specifications.

3. Testing Laboratory:

a. Both qualification and production quality control tests shall be performed by either an independent testing laboratory or a qualified manufacturer's laboratory. If an independent testing laboratory is selected, it shall be a member of the American Council of Independent Laboratories. If a manufacturer's laboratory is selected, it shall satisfy the requirements of the American Council of Independent Laboratories' "Manual of Practice - Quality Control System - Requirements for a Testing and Inspection Laboratory," and ASTM E329.

b. The selected laboratory shall use the proper equipment and qualified testing personnel for elastomeric and metal material and assembly performance testing such as are described in this Section. Approval is required by the VTA prior to qualification testing. Submit the information specified below to the VTA for approval.

1) The name and address of the laboratory.

2) A description of the facilities and testing equipment that will be assigned for this testing.

3) The names, experience, and qualifications of the personnel that will be assigned for this testing.

4) A list of experience in testing other fasteners or fastener-like assemblies by the laboratory.

4. Testing Equipment: Testing equipment shall be in good operating condition, of adequate capacity and range, and accurately calibrated. Testing equipment shall be in calibration with standards which are certified and traceable to the National Bureau of Standards within one year immediately preceding the test date. Copies of calibration certificates shall be submitted with test reports in accordance with the Special Conditions, Section SC-6.

5. Documentation: In conjunction with the specified tests, the documentation specified below shall be submitted to the VTA for review and approval. These shall be submitted within 30 days after notice to proceed.

a. Test Program Plan: A test program plan shall be submitted. In this plan, the Contractor shall identify his approach for accomplishing each of the specified qualification and pro-duction quality control tests. The projected schedule for test procedure submittals, test executions, and test results report submittals shall also be included.

b. Test Procedures: Procedures shall be submitted for each test, describing the objective, equipment, and instrumentation that will be used, procedure to be implemented, and the anticipated, as well as acceptable, results. Working drawings detailing test equipment and set-up of fastener or fastener component that will be tested shall be included.

c. Test Report:

1) A separate report of test results for each test shall be submitted, and shall include original data calculations, test procedure references, test equipment identification, test personnel, date of test, specified requirements, actual test results, non-conformances, if any, and interpretation of the results. Conformance or deviations shall be highlighted in a Report Summary.

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.

1.09 QUALIFICATION TESTS

A. General: All qualification tests shall be successfully completed to the satisfaction of the VTA prior to commencing any production of fasteners or fastener components. Qualification tests on specific components may be waived by the VTA providing that satisfactory evidence, including certified qualification test reports, is submitted with the Test Program Plan and approved by the VTA. The evidence shall include certified test procedures with test apparatus working drawings, as specified in Articles 1.08 B.5 and 1.07. The evidence shall adequately prove that satisfactory qualification tests have been conducted on components of identical design to that specified in these Specifications. The tests are described in detail in Articles 1.09 through 1.12. The following is a summary listing of the tests that shall be satisfactorily conducted to complete the qualification test program. Evidence of qualification test results submitted in lieu of actual tests must be current within one year of the date of the submittal and must be specific in identifying the test requirement for which the certified test report is being furnished. This alternative shall not be used as a substitute for the requirements of the Special Conditions relative to alternate designs or "equals". Failure of any certified qualification report to satisfy the requirements of these Specifications shall not relieve the Contractor and manufacturer from the requirements for qualifications testing as detailed here.

B. Testing of Elastomer: The testing of elastomers shall be performed as specified in Article 1.12. All elastomer qualification tests shall be successfully completed and approved by the VTA prior to commencing qualification testing of fastener assemblies.

C. Testing of Anchor Assemblies: The testing of anchor assemblies shall be perform as specified in Article 1.14. All eight anchor assemblies shall have successfully met the test requirements and been approved by the VTA prior to commencing qualification testing of fastener assemblies.

D. Testing of Fastener Body Metal: The testing of fastener body metal shall conform to Article 1.13. Each metal specimen shall have met the minimum impact requirements and be approved by the VTA before fastener assembly qualification testing proceeds.

E. Testing of Fastener Assemblies:

1. Following review and approval of the Shop Drawings by the VTA and the successful completion of the qualification testing of the elastomer, anchor assemblies, anchor inserts, and fastener body metal, a minimum of eight complete fastener assemblies and twelve shim plates shall be manufactured for qualification testing. From these, four fastener assemblies and four shim plates shall be delivered to the VTA to be retained for design control reference and further test use. The remaining four fastener assemblies and eight shim plates shall be assembled and installed on concrete test blocks for testing in accordance with Article 1.15. Testing and qualification of restraining rail type fastener assemblies shall be conducted by the same methods and in the same quantities as provided for single rail type fastener assemblies. Testing of additional quantities of anchor assemblies for restraining rail type fastener assemblies shall not be required.

2. If the two-fastener alternative testing arrangement described in Article 1.15B. is selected, the quantities of fasteners and shim plates required shall be revised. A minimum of sixteen complete fastener assemblies and twenty shim plates shall be manufactured. From these, eight fastener assemblies and four shim plates shall be delivered to the VTA, and eight fastener assemblies with sixteen shim plates shall be used for the testing.

F. Test Failure: Should any fastener assembly fail a test, the entire sequence of tests, as specified in Article 1.15, shall be performed on a new fastener assembly. If the fastener assembly must be modified to pass any test, Shop Drawings of the new design shall be approved by the VTA before performance testing is continued. A new lot of at least eight fastener assemblies of the new design shall be produced and all tests performed on the new fastener design. After acceptance of the new design, the revision, approval and test cycle shall continue within twelve weeks until fastener assemblies are approved. 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 witnessing tests, shall be at no additional expense to the VTA. After the VTA has approved the fastener assembly design, changes in the design, materials, and manufacturing process shall not be made without written approval by the VTA. Should the Contractor propose a change, the VTA may require retesting of the 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 test at no additional cost to the VTA.

1.10 PRODUCTION QUALITY CONTROL TESTS

A. General: Following successful completion of the qualification tests, approval of the qualification test reports by the VTA, and start of fastener assembly manufacturing, elastomer samples and fasteners selected from regular production shall be subjected to testing to ensure mat high quality standards are maintained and that design requirements set forth in these specifications are met through the completion of production. The required production quality control tests shall be conducted as specified in Article 1.11 and 1.14. The following is a summary listing of the production quality control tests that shall be satisfactorily conducted.

B. Testing of Elastomer: Provide certification of the elastomer used in the manufacturer of the fasteners, verifying compliance of the elastomer used in each fastener production lot, as described in Article 1.11, with the testing requirements specified in Article 1.11 at least seven days prior to shipment of fasteners:

C. Testing of Fastener Assemblies:

1. Production quality control testing of fasteners shall be performed on two fasteners from the first fifty fasteners produced and on two fasteners from each production lot. Fasteners shall be selected for testing by the VTA.

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 VTA 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. Rejected fasteners shall be disposed of in accordance with all applicable rules & regulations at no additional cost to the VTA. Replacement fasteners shall be procured and tested as required at no additional cost to the VTA.

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 VTA. Production quality control testing of fastener assemblies shall include the tests specified in Article 1.11 to 1.14.

1.11 TESTING OF ELASTOMER

A. Preparation of Test Specimens: Elastomer tests shall be performed on each of two specimens that are identical in all respects to the elastomer proposed for use in fasteners. Use a separate pair of specimens for each test. Use specimens taken from a batch of compound used for making the elastomeric component of the fastener and having a cure equivalent to the cure of the elastomeric component Before testing, condition specimens for at least seven days at 73.4ºF and 50 percent relative humidity.

B. Effect of Elastomer Type on Tests: Test shall correspond to the rubber content specified in 2.01 A.3.e.

C. Hardness Test:

1. Test Method: ASTM D2240.
2. Acceptance Criteria: 40 to 75 Durometer, Shore A.

D. Tensile Strength Test:

1. Test Method: ASTM D412.
2. Acceptance Criteria: 1,500 psi minimum.

E. Ultimate Elongation Test:

1. Test Method: ASTM D412:
2. Acceptance Criteria: 350 percent, minimum.

F. High Temperature Compression Set Test:

1. Test Method: Test for 22 hours in accordance with ASTM D395, Method B. The test shall be conducted at a temperature of 158ºF.
2. Acceptance Criteria: The set shall not exceed 25 percent.

G. Low Temperature Compression Set Test:

1. Test Method: Using ASTM D1229, test for 70 hours at a temperature of 14ºF.
2. Acceptance Criteria: The compression set at 30 minutes after release (plus 30 reading) shall not exceed 65 percent.

H. Accelerated Aging Test:

1. Test Method: Using ASTM D573, age the elastomer for 70 hours at a temperature of 158ºF. Measure and record the change in hardness, tensile strength and ultimate elongation.
2. Acceptance Criteria: The tensile strength shall exceed 1,125 psi the ultimate elongation shall exceed 310 percent, and the change in hardness, measured on the Durometer A scale, shall not exceed 10 points.

I. Resistance to Ozone Cracking Test:

1. Test Method: Prepare test specimens in accordance with Procedure A of ASTM D518. Test the specimens in accordance with ASTM D 1149 at a temperature of 104ºF and ozone concentration of 50 pphm.

2. Acceptance Criteria: The elastomer shall not exhibit cracking at the end of a 100-hour exposure.

J. Oil Absorption Test:

1. Test Method: Determine the volume change of the elastomer using ASTM D471. Conduct one test with ASTM No. 3 oil at a temperature of 73.4ºF for 70 hours and conduct the other test using a different sample with ASTM No. 1 oil at a temperature of 73.4ºF for 70 hours.

2. Acceptance Criteria: The volume change for the No. 1 oil shall not exceed minus ten or pins 20 percent; and for the No. 3 oil, the volume change shall not exceed 100 percent.

K. Adhesion to Metal Test:

1. Test Method: 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, and adhesives in preparing the test specimen as are used in the production of the fastener body.

2. Acceptance Criteria: The failure shall be a Type R, in which the elastomer tears before the elastomer bond to the metal parts.

L. Flame Spread and Smoke Generation Test:

1. Test Method: Test the elastomer in accordance with the ASTM E162 to determine the flame propagation index. Test the elastomer in accordance with NFPA 258 in both the flaming and non-flaming modes to determine the smoke generation specific optical index.

2. Acceptance Criteria: 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 VTA for information only.

M. Electrical Resistivity Test:

1. Test Method: ASTM D257. For testing under wet conditions, the elastomer shall be immersed for 24 hours in potable water with a resistivity of 1,000 to 1,500 ohm-cm. Resistivity of potable water shall be adjusted to the required range by the addition of sodium chloride.

2. Acceptance Criteria: The elastomer shall have a minimum volume resistivity of 1012 ohm-centimeters under dry conditions and a minimum of 1011 ohm-centimeters after 24 hours immersion in water.

N. Water Absorption Test:

1. Test Method: Determine the change in weight of the elastomer due to absorption of water using ASTM D570. Immerse the specimens in distilled water for 24 hours at a temperature of 73.4ºF.

2. Acceptance Criteria: The elastomer shall have a maximum increase in weight of 1.0 percent.

1.12 TESTING ANCHOR ASSEMBLIES

A. Test Preparation:

1. Eight anchor assemblies identical in design to those specified for supply with the fasteners shall be required to perform the following tests. Two separate anchor assemblies shall be used for each of the three tests. For the acceptance of anchor design, each anchor assembly shall satisfy the test requirements and the test results shall not be averaged.

2. The anchor inserts shall be embedded in a reinforced concrete test block which is 8 feet long, 2 feet 2 inches wide, and 7-1/2 inches high. The sides shall be vertical and the top and bottom shall be horizontal. The inserts shall be positioned as they would be in track for two fasteners at 30 inches apart measured parallel to the rail. The inserts should 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. The test set-up is shown graphically on Figure 3.

3. The concrete test block shall have a 28-day compressive strength of between 4,000 and 4,400 psi as determined by ASTM C39. Provide four test cylinders, and test two at seven days and two at 28 days. The tests on the inserts shall not begin until the concrete has reached the specified 28-day compressive strength.

4. The reinforcing steel shall be placed as shown on Figure 3. Use ASTM A615, Grade 60 steel.

5. The anchor bolts shall be threaded into the inserts to at least 1-1/4 inch thread engagement before load application.

6. The test apparatus working drawings shall be submitted to the VTA for approval with the test procedures.

B. Restrained Pullout Test:

1. Test Method: Place a 3-1/2 inch x 3-1/2 inch x 1/2 inch thick steel plate with a one inch diameter hole in its center, over an anchor bolt. Apply for one minute an upward vertical load, starting at 1,000 pounds and increasing to 20,000 pounds, to the anchor bolt with the reaction force bearing against the steel plate. Repeat the test on one other anchor bolt.

2. Acceptance Criteria: 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.

C. Unrestrained Pullout Test:

1. Test Method: 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 16,000 pounds occurs, be held at 16,000 pounds for at least one minute and be released. Repeat the test on one other anchor bolt.

2. Acceptance Criteria: There shall be no evidence of concrete cracking or failure of bond between either of the two bolts or inserts, and concrete.

D. Torsion Test:

1. Test Method: An anchor bolt shall be subjected to a torque at least 100 percent greater than the design installation torque submitted with the installation requirements. The load shall be

held for three minutes and released. Repeat the test on one other anchor bolt.

2. Acceptance Criteria: There shall be no evidence of failure of the bond between either of the two bolts or inserts, and concrete.

1.13 TESTING FASTENER BODY METAL – CHARPY IMPACT TEST

A. Test Method: Prepare three Charpy impact test specimens in accordance with ASTM E23 from the same metal used for the top of the fastener body. If different grades of steel or iron are used, prepare three specimens of each. Conduct a Charpy impact test on each specimen at a temperature of 70ºF in accordance with ASTM E23. The test report shall include the information in Paragraph 12 of ASTM E23.

B. Acceptance Criteria: The fracture energy shall be greater than 3 foot-pounds for iron and 15 foot-pounds for steel

1.14 TESTING FASTENER ASSEMBLIES

A. Test Preparation:

1. Except as described in Paragraph 1.12B, a minimum of four complete fastener assemblies are required to conduct the tests. One fastener shall be assembled and mounted on each of four concrete test blocks, which shall be designated as A, B, C, and D. The tests shall be 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 115RE 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 test apparatus working drawings, as approved by the VTA and as outlined in the approved test procedures. Two 1/4-inch shim plates 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 VTA. The torque of each bolt shall be measured and noted in the test report.

3. The anchor inserts shall be spaced to match the fastener at the middle lateral adjustment setting. The inserts shall be set in a reinforced concrete block in accordance with Articles 1.12.A.2 through 1.12.A.5, except that only two anchor inserts shall be placed at the center of the block and the concrete block shall have a minimum length of 30 inches.

4. Before commencing each test, the fastener and concrete test block shall be stabilized at a temperature of 73.4°F plus or minus 7.2°F, for at least four hours. Testing shall be performed within the same temperature range except as otherwise specified herein.

5. Except as otherwise noted, the test loading shall be applied to the rail at the centerline of the fastener. The test report shall clearly indicate the performance of each of the fasteners separately. Failure of any of the fasteners will be sufficient cause for the rejection of the fastener design.

B. Alternative Test Preparation:

1. Instead of using one fastener, each test may be performed on a pair of fastener assemblies at 30 inches center-to-center spacing, with a section of 115RE rail not less than 42 inches long mounted and cupped thereon. Each fastener shall be assembled as described in 1.14A for one

fastener.

2. For the two-fastener testing arrangement, the total loading specified for each test shall be doubled. Vertical or lateral loads shall be 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 separately. For the acceptance of fastener design, each fastener shall satisfy the test requirements without failure.

3. The concrete test block shall be as described in Article 1.12.A, except it shall have a minimum length of five feet, with two pairs of anchorage inserts at 30 inches spacing center-to-center centered within the test block.

C. Vertical Load Test:

1. Test Method: Each fastener shall be vertically loaded to 10,000 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 500 pounds to a maximum load of 10,000 pounds at a rate not less than 100 pounds per minute nor 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 measure and record the vertical deflection of the rail head to be nearest 0.001 inch. The load shall be removed and the final position of the rail head measured and recorded.

2. Acceptance Criteria:

a. The fastener stiffness shall be calculated as the slope of a straight line determined by a linear least-squares regression of each load versus each deflection for loads between 2,000 pounds and 10,000 pounds. The fastener stiffness shall be within 20 percent of 90,000 pounds per 1inch. The load versus displacement curve shall lie within the Limits identified in Figure 4.

b. The tangent to the load-versus-deflection curve at each load between and including 2,000 pounds and 8,000 pounds shall be within 20 percent of the fastener stiffness determined above. For the purpose of calculation, the tangent (T) to the load versus deflection curve at each deflection, X_n, and each load, P_n, shall be approximated as:

$$T = (P_{n+1} - P_{n-1})/(X_{n+1} - X_{n-1})$$

where P_n is the load at deflection X_n.

c. The total deflection of the elastomer at the 10,000 pounds load shall not exceed 30 percent of the uncompressed thickness. After removal of the maximum load of 10,000 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, 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.

d. The values obtained when this test is repeated, after performance of other tests, on a fastener shall be within 15 percent of the initial test values.

D. Vertical Uplift Test:

1. Test Method: Apply a vertical load to the center of the rail head at the centerline of the fastener normal to the rail, alternating continuously from a downward load to an upward load. The upper and lower peaks per cycle shall be increased in increments of 200 pounds each cycle up to a maximum load of 2,400 pounds. The loads and deflections shall be continuously measured to the nearest 0.001 inch and immediately recorded on a load-versus-time graph and deflection - versus- time graph, respectively. 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.

2. Acceptance Criteria: The absolute vertical deflection of the fastener for an upward load of 2,000 pounds shall be within 135 percent of the absolute deflection for the 2,000 pounds downward vertical load as determined from the vertical load tests. When the vertical load is continuously varied from vertical downward to vertical uplift loads, there shall be no indication of backlash or freeplay at times when the load or the deflection changes direction. After removal of the maximum load, the rail shall, within two minutes, return to within 0.005 inch of its original position. At no time during the test shall a fastener component, including the anchor assembly and the test block, exhibit a sign of failure by slippage, yielding, or fracture.

E. Lateral Load Test:

1. Test Method: While applying a constant vertical load of 10,000 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, shall be applied horizontally to the gauge side of the rail head at the location of vertical load. The horizontal force shall be applied 0.625 inch below the top of the rail. For each lateral 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. Plot the recorded values for lateral load versus deflection.

2. Acceptance Criteria: The lateral load versus deflection curve shall lie within the envelope shown in Figure 5. After removal of the lateral load, the difference between the original and final positions of the gauge line shall not exceed 0.062 inches. At no time during the test shall a fastener component exhibit a sign of failure by slippage, yielding, or fracture.

F. Lateral Restraint Test:

1. Test Method: Two equal lateral loads increasing simultaneously in increments of 500 pounds up to a maximum load of 3,000 pounds for each load, for a total load of 6,000 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: The difference between the original and final positions of the gauge line after removal of load shall not exceed 0.062 inch. The lateral deflection of the rail head when fully loaded shall be between 0.0625 and 0.125 inch from the original gauge line of the rail. At no time during the test shall a component show signs of slippage, yielding, or fracture.

G. Longitudinal Restraint Test:

1. Test Method: For a fastener assembly with two rail clips, apply a load longitudinally to the

rail at its base increasing in increments of 200 pounds up to a total load of 5,000 pounds or until the rail deflects 0.6 inches 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.

2. Acceptance Criteria: The difference between the initial and final positions of the rail after removal of load shall not exceed 0.125 inch plus the slippage distance of the rail relative to the fastener top plate. The longitudinal load versus deflection curve, when plotted on a graph similar to Figure 6, shall lie entirely within the shaded limits. At no time during the test shall a fastener component exhibit a sign of failure by slippage, yielding, or fracture, except for the slippage which occurs between the rail and the fastener top element and clips.

H. Voltage Withstand Test:

1. Test Method: Prepare a fully assembled fastener and apply a dc potential of 10,000 volts between the rail head and the metal base element and/or fastener insert assemblies for one minute.

2. Acceptance Criteria: The elastomer shall withstand this test with no visible damage such as splits, cracks, pinholes or fractures. There shall be no evidence of arcing, arc tracking, or other voltage breakdown.

I. Electrical Resistance Test:

1. Test Method:

a. A complete, fully assembled fastener, as specified herein, shall be tested for electrical resistance. Before assembly, metal parts, anchoring devices, rail clips, elastomer surfaces and all other ancillary parts associated with the fastener shall be clean and dry. Assemble the fastener with a section of 115RE rail, not less than one foot in length. Mount the test fastener on a 1/4 inch thick metallic ground plate sized to extend 1/2 inch beyond all edges of the fastener. Use anchor assemblies supplied for use in actual field installation, to mount the fastener to the ground plate. Use the same number of bolts (or other devices) as will be used to anchor the fastener in service. Verify mat all parts which should be in electrical contact do not exhibit excessive contact resistance because of improper assembly or other causes. This shall apply to, but not necessarily be limited to the areas specified below.

1) Rail to rail-plate interface.

2) Rail clip and rail.

3) Anchor bolts and bottom fastener plates (if present).

4) Anchor bolts and ground plate.

b. Dry Conditions: Twenty-four hours prior to testing, store the assembled fasteners in a clean, dry environment with ambient conditions of 60°F to 80°F and 50 to 70 percent relative humidity. Apply 100 volts (minimum) dc between the rail head and the ground plate for three minutes. Measure the applied voltage and resulting current flow, or directly measure the resistance with an accuracy of plus or minus two percent. Instrumentation used for direct measurement shall have a minimum 100 volt output capability.

c. Wet Conditions: Perform this test on the same fasteners mat passed the dry electrical resistance tests. Place the assembled fastener in a nonmetallic trough or other suitable container. Size the container such that mere is a minimum of two-inches between the sides and bottom of the fastener/ground plate assembly and the sides and bottom of the container. In the event more than one fastener is placed in the same container, maintain a two-inch clearance between the edges of the ground plates on adjacent fasteners and the clearances cited above. Pour water into the container to a level midway up the rail web covering all surfaces of the fastener. Maintain this level of immersion for ten minutes. Ambient temperature of fastener surfaces (prior to immersion), water and air shall be 60°F to 80°F. Relative humidity shall be 50 to 70 percent Water resistivity shall be 1,000 to 1,500 ohm-cm (use potable water and adjust resistivity by addition of sodium chloride). Drain the water from the container to a level 1/2 inch below the ground plate, and without drying or otherwise disturbing the fasteners or creating a condition mat causes the fastener surfaces to dry, measure the resistance within 15 seconds after draining specified below.

1) Apply 100 volts between the rail head and the ground plate for a period of 15 seconds.

2) Measure the applied voltage and resulting current flow between the rail head and the ground plate with an accuracy of plus or minus two percent and calculate the dc wet resistance, or directly measure the resistance with an accuracy of plus or minus two percent Instrumentation used for direct measurement shall have a minimum 100 volt output capability.

3) Repeat the resistance measurement every five minutes for the first hour, every ten minutes for the second hour, and every 15 minutes thereafter to establish the wet resistance versus time characteristics of the fastener. Make the tests for at least two hours after wetting. The tests can be terminated after the two hour test period when any three consecutive measurements are at least one mega-ohm, or after another two hour test period, whichever comes first.

2. Test Acceptance Criteria:

a. Dry Conditions: The minimum dc resistance shall be 20 mega-ohms.

b. Wet Conditions: A minimum resistance of one mega-ohm for the average of three consecutive readings within two hours after wetting. The difference between each of the three readings and the average shall not exceed ten percent of the average.

J. Electrical Impedance Test:

1. Test Method: A complete, fully assembled fastener, as specified, shall be tested for electrical impedance. A potential of 50 volts AC RMS shall 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 impedance after three minutes shall be measured with an accuracy of plus or minus two percent and recorded for each frequency. Upon approval by the VTA, electrical resistance may be calculated by measuring current flow, and impedance may be calculated from the measurements of

resistance and capacitance using the impedance equation that applies to a resistance and capacitance in parallel.

2. Acceptance Criteria: The minimum impedance for any frequency between 20 Hz and 10 kHz with 50 volts AC RMS shall be 10,000 ohms.

K. Corrosion Test:

1. Test Method: The fastener, without loose components, shall be exposed to a five percent chloride solution in accordance with ASTM B117 for 744 hours.

2. Acceptance Criteria: 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 and there is no pitting. There shall be no evidence of adhesion loss of adhesive coating. In areas where prior testing has removed the protective coatings, the surface rust grade specified above shall be used for judging acceptance.

L. Vertical and Lateral Repeated Load Test:

1. Test Method: Apply a load on the rail head center so as to produce a vertical downward load of 10,400 pounds on the fastener. Apply lateral loads to the gauge side of the rail head 0.625 inch below the top of rail 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. Vertical and lateral loads versus time shall be sinusoidal. For the qualification testing program, the test shall be conducted for 3,000,000 cycles. For production quality control testing, the test shall be conducted for 500,000 cycles. The anchor bolts may be retorqued to their initial torque once during this test prior to 500,000 cycles. The loading frequency shall be regulated to prevent the temperature of the fastener components from exceeding 122°F. The rail clips shall not be repositioned nor threaded elements retorqued without written approval of the VTA.

2. Acceptance Criteria: 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 evidence of failure by slippage, yielding, abrasion, or fracture at any time during the test. The rail shall exhibit no evidence of wear or grooving mat could contribute to failure of a rail.

M. Repeated Load Test With One Anchor Bolt Loosened:

1. Test Method: 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 1/4 inch, repeat the vertical and lateral repeated load test for 15,000 cycles.

2. Acceptance Criteria: The fastener shall withstand the specified total number of cycles of loading with no evidence of failure by slippage, yielding, or fracture. The rail shall exhibit no evidence of wear or grooving mat could contribute to failure of a rail.

N. 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 10,400 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 122°F. Do not reposition rail clips or retorque threaded elements without written approval of the VTA.

b. During the final 500,000 cycles, a longitudinal load shall be applied to the rail at its base. 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. Acceptance Criteria: The fastener shall withstand 1.5 million cycles of load application with no evidence of failure. Upon visual inspection, no component of the fastener shall exhibit evidence of failure by yielding, abrasion, slippage, or fracture. 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.

O. Push-Pull Test:

1. Test Method:

a. The rail end shall be supported on a roller or other frictionless support properly elevated to prevent the longitudinal load from binding the rail in the fasteners. Apply a cyclic longitudinal load at the base of the rail to slip the rail approximately 1/2 inch back and forth about its initial position for a total of 2,000 cycles without repositioning rail clip or retorquing bolts. The 1/2 inch slip shall be measured with respect to a fixed point on the testing machine. Following this, components shall be checked against the acceptance criteria. Next, a cyclic longitudinal load at the rail base shall be applied to slip the rail approximately 1/8 inch back and forth about its initial position for a total of one million cycles.

b. Repositioning of the rail clip will not be allowed during the second phase of the test. Loading frequency shall be regulated to prevent the temperature of components from exceeding 122°F. Clean water may be applied occasionally as a spray in order to keep the temperature below 122°F.

2. Acceptance Criteria: The fastener shall withstand the specified number of cycles of load application with no evidence of failure. Upon visual inspection, no component shall exhibit evidence of failure by slippage, yielding, or fracture at any time during the test, nor shall a rail clip show evidence of sliding out or backing out of its hold-down housing more than 1/16 inch. The rail shall exhibit no evidence of wear, beyond minor polishing and grooving, that could contribute to failure of a rail.

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 3,000 and 7,000 pounds at a rate of between ten and 20 hertz. 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-trough force to peak-to-trough deflection from the recorded data. 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 beginning at zero pounds and increasing in 1,000 pound increments to a maximum of 8,000 pounds at a rate not less than 100 pounds per minute nor more than 1,000 pounds per minute shall be applied at the centerline of die fastener. For each increment of load between 2,000 and 8,000 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 3,000 and 7,000 pounds.

2. Acceptance Criteria: The dynamic stiffness shall not exceed 1.4 times the static stiffness.

Q. Heat Aging Test:

1. Test Method: Age test the fastener body, without rail, concrete test block, rail clips or anchor assemblies, in an air oven for 336 hours at a temperature of 158°F in accordance with ASTM D573.

2. Acceptance Criteria: This is a conditioning process that is required for the test sequence and there is no acceptance criteria.

1.15 PACKAGING, SHIPPING, AND UNLOADING

A. General:

1. The Contractor shall replace all fasteners damaged during packaging, shipping, and unloading with new units at no additional cost to the VTA.

2. Fasteners used in qualification testing shall be delivered separately to the VTA and shall not be included in the final delivered quantity.

3. All containers shall be clearly marked with the identification of item contained, Supplier's name, shipping date, number of pieces, destination (including VTA designation), and gross weight.

B. Packaging:

1. Pack fastener bodies, rail clips, anchor bolts and anchor assemblies separately in units convenient for handling. The fastener bodies shall be in weatherproof containers, banded on pallets for forklift handling. Anchor bolts, and anchor assemblies shall be packed in sealed, waterproof, steel or heavy-duty plastic barrels, or other approved weatherproof container. All containers and/or pallets containing non-metallic parts shall specifically protect the components from damage by ultraviolet light and shall be capable of withstanding outdoor storage without additional cover for at least one year.

2. All fastener shipments shall be adequately prepared to preclude damage during shipment.

3. Package and label spare parts and replacement materials in moisture proof containers suitable for shipment and storage. Attach copies of shipping list within moisture-proof and see-through envelopes in the package so mat the list is readable from the exterior of the package.

C. Shipping: All fasteners shall be shipped to the San Jose/Milpitas Area in accordance with the schedule and general delivery locations identified by the VTA. Ship spare parts and materials as directed by the VTA. Contractor shall anticipate a maximum of three separate drop-shipment points, each within 15 miles of VTA's main offices in San Jose, California.

D. Handling, Unloading, and Stacking: Fastener bodies and associated hardware shall be unloaded and stacked by a method that will prevent damage to or loss of products. The unloading and stacking sites are accessible by truck and will be provided to the Contractor no later than approval of the submittal identifying the direct fixation fastener manufacturer. The Contractor shall furnish all equipment, labor, rigging, dunnage, and other materials necessary to perform the work.

E. Unloading: Unload the spare parts and materials in a manner that will prevent damage to the packages and the contents. The VTA will open the packages and inspect spare parts and materials for damage. Damaged parts and materials will be returned to the Contractor to be replaced with undamaged parts and materials, at no additional expense to the VTA. Damage to any moisture-proof containers for the spare parts and replacement materials shall be repaired at no additional expense to the VTA.

F. Delivery: Deliver spare parts and materials not later than the date of Final Acceptance at a location in the San Jose / Milpitas area specified by the VTA

1.16 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Fastener Body:

1. General Requirements:

a. The rail fastener body shall consist of an elastomeric element bonded to metal top and base elements.

b. The base of the fastener body in contact with the concrete trackbed or height adjustment shims shall be flat and horizontal for tangent track, with no projections into the concrete pad or height adjustment shims.

c. The stability of the rail fastener in any lateral and longitudinal direction shall not be dependent solely on the strength of the bond of the elastomer to metal.

d. The fastener shall have full bearing on the elastomer in all positions of lateral adjustment.

e. Exposed metal surfaces of the fastener body that are not covered with elastomer shall be coated with the primer and material used to form the bond of elastomer to metal. This coating shall protect the exposed surfaces of the metal parts from corrosion and shall protect the elastomer-to-metal bond.

f. All fastener components 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.

2. Metal Components:

a. The metal top shall each be one-piece rolled, forged, or cast steel or ductile iron.

b. The metal top shall be designed with sufficient material strength, thickness, and shape to withstand the loading and fatigue requirements of the specifications and the transit systems.

c. The metal top element shall be flat, except for rail clip and rail seat shoulder projections, and continuous. The rail seat shall be flat, with either a flat or a 1:40 slope down on the gauge side for rail cant, as applicable. The rail seat and clip mating surfaces shall be smooth, free from injurious warp and other imperfections in surface and projecting fins of metal caused during forming.

d. Rolled steel plate shall be minimally, of ASTM A36 steel The fracture energy at 70°F (21.1°C) in accordance with ASTM E23 shall be greater than 15 foot-pounds.

e. Ductile iron castings shall be minimally, Grade 65-45-12 in accordance with ASTM A536. They can be as-cast, but may be heat treated. The chemical composition shall meet the acceptable level per SAE J434. The Brinell hardness in accordance with ASTM E 10 shall be within 156-217 BHN. The microstructure shall be within the limits set by SAE J434. The fracture energy at 70°F in accordance with ASTM E23 shall be greater than 3 foot-pounds.

f. Rail: The fastener top element shall be designed to support 115RE rail (types SSF and SSC), or 115RE running rail with modified 115RE restraining rail (types RRF and RRC).

3. Elastomer:

a. Any portion of the elastomer bonded between metal top and base elements, such as between upturned or downturned metal on the sides, shall have a thickness of not less than 1/2 inch.

b. Recesses or notches which penetrate the metal top element and expose the elastomer shall be tree draining with not less than seven percent slope if draining in a direction perpendicular to the rail or not less than six percent if draining in a direction parallel to the rail.

c. Elastomer surfaces shall be smooth with a finish and appearance equal to or better than an F-3 designation in accordance with the RMA Rubber Handbook.

d. The elastomer shall be natural rubber based as defined in ASTM D 1566 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 elastomer may also be a neoprene (polychloroprene) or blend with over 50 percent polychloroprene that otherwise meets the performance requirements of these Specifications.

e. The Durometer A hardness shall be between 60 and 80 as measured in accordance with ASTM D2240.

B. Rail Cup Assemblies:

1. The gauge and field sides of the rail base shall be held to the metal top element of the fastener body by Pandrol, Inc. Type E-2055, Pandrol Inc. Type PR-601A, or approved equal clips. The rail clip shall be a resilient type, non-threaded spring steel clip. Spring-wedge type rail clips shall not be permitted.

2. Neither the rail clip nor the rail clip holder shall make point contact with the rail. The contact area shall not be shorter than one inch measured along the rail and not smaller than 0.15 square inch in area.

3. The rail cup assembly shall not include any elastomeric components.

4. The rail clip assembly shall be designed to enable installation and removal without damage to the fastener body, elastomeric elements, cup holder, clip, or rail.

5. The rail clip shall be a commonly produced design by the rail cup manufacturer. Underbent or overbent alterations of the commonly produced clip will not be accepted.

6. The rail clips shall have at least a seven year track record of successful performance on other rail transit or railroad projects.

7. The bars used for rail clips shall be free of injurious defects and shall have a workmanlike finish consistent with good hot-rolling practices for bars intended for use in springs.

8. The rail clip shoulders shall provide parallel alignment with the base of the rail, shall hold the rail clip in proper tension and shall ensure the rail clips will not back out or work loose from the proper installation position for the life of the product. Use of weld-on shoulders shall be subject to specific approval of VTA.

C. Anchor Assemblies:

1. General Requirements:

a. Each fastener shall provide two anchor assemblies, each consisting of an anchor bolt, anchor insert, washers, and other components required for lateral adjustment of the fastener.

b. The anchor assembly shall anchor the metal base element to the concrete trackbed, and be perpendicular to the fastener base. Anchor bolts shall not penetrate or contact the metal top element.

c. The necessary lateral adjustment of the fastener shall be integral with the anchor assembly.

2. Anchor Bolts:

   a. The anchor bolts shall be ANSI B18.2.1, 7/8 inch diameter, heavy hex. The length shall be sufficient to provide at least 1-1/4 inch thread engagement with the anchor insert threads when the fastener is installed at the maximum vertical adjustment, using 1/2 inch of shim plates. The threads shall be 7/8-9 UNC-2A in accordance with ANSI B1.1 and ANSI B1.3.

   b. The anchor bolts shall be SAE J429, Grade 5 steel. Bolts, including threads, shall be electrodeposited with zinc in accordance with ASTM B633, Type II, SC 2.

3. Washers:

   a. Both plain and lock washers shall be 7/8 inch diameter, carbon steel, and zinc-electrodeposited in accordance with ASTM B633, Type II, SC 4.

   b. Plain washers shall be ANSI B18.22.1, Type B, Regular.

   c. Lock washers shall be ANSI B18.21.1, helical spring, Extra Duty.

4. Anchor Inserts:

   a. Anchor inserts shall be non-welded female type, and shaped to prevent rotation and pullout. The total length shall not exceed 5 inches. The centerline locations for the inserts shall be as indicated in Figure 1. The insert shall remain within the envelope indicated on Figure 1 in all positions of adjustment.

   b. The inserts shall be threaded to receive the anchor bolts using 7/8-9 UNC-2B threads in accordance with ANSI B1.1. The threads shall be coated with a nonconductive rust inhibitor to prevent rust formation during pre-installation storage, yet which will not hinder the threading on and tightening to proper torque of the anchor bolts during installation in track. The nonconductive rust inhibitor shall be indicated and specified on the shop drawings for approval by the VTA or its designee.

   c. The top of the insert in the installed position shall have a smooth and flat bearing surface with an area of at least one square inch.

   d. A nylon or plastic pull-away type plug capable of sealing the insert threads against concrete seepage and be easily removable shall be provided in each insert. Plugs shall be capable of reinsertion and reuse.

   e. The insert shall be SAE J995, Grade 5 steel.

   f. Fusion Bonded Epoxy Coating.

      1) 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 approved equal.

      2) The fusion bonded epoxy coating shall be applied to all surfaces of the

insert except for the threaded hole that must remain uncoated. The coating shall be applied in accordance with ASTM A775, 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 SP1.

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 gauge.

e) The coating shall be uniform and free of runs, sags and chips. The coating shall be 100 percent holiday-free.

f) The bend test specified in ASTM A775 is not required.

5. Additional Components:

a. Other components required by the design shall have sufficient material strength and size to withstand loading and fatigue properties of the testing, installation, and in-track service.

b. Metal components shall be steel or iron of the same material with which they match or intermesh to avoid corrosion due to galvanic action between dissimilar metals.

c. These components shall have material hardness consistent with those of the metal base element and anchor assembly parts with which they match or intermesh, to minimize wear from operating vibration and lateral adjustment.

d. Submit the material description and manufacturing method of the components with the fastener shop drawings.

D. Shim Plates:

1. It is the intention of these Specifications that direct fixation fastener assemblies will be installed on second pour concrete pedestals to exact elevations without die use of height adjustment shim plates. However, the use of shim plates when required to raise fasteners to the exact height to fully support the running rail is unavoidable and a requirement for satisfactory installation.

2. Shim plates for use in adjusting the height of direct fixation fastener assemblies shall be provided for each bid item as shown in the table at the end of this Section.

3. Shim plates shall be of two sheet metal thicknesses, 1/8 inch and 3/8 inch nominal thickness, and shall be furnished to fastener assemblies. The shim plates used for qualification and

production quality control tests shall be the same shim plates delivered for installation per these specifications.

4. For the purpose of design, qualification and testing, not more than two shim plates and not more than 1/2 inch of shim height shall be installed under a direct fixation fastener.

5. Shim plates shall be fabricated from mild sheet steel and shall be free from kinks, bends, or curl of the plate edges due to stamping or shaping in the production process. Plates shall be free of sharp edges, to the touch, prior to galvanizing.

6. Shim plates shall provide 1/4 inch projection beyond the sides and ends of the fastener and/or elastomer pad. Design shall provide slots in the shim plate to allow it to be slipped in and out from under the elastomer pad or fastener assembly base plate and anchor bolts without removing the anchor bolts.

7. Shim plates shall be designed to prevent vibrating loose during service. Slot size shall be designed such that with the shim plate in the installed position under the fastener assembly, the bearing area of the top face of each anchorage insert against the shim plate is a minimum of 9/16 square inches.

8. Shim plates shall be hot-dip galvanized after fabrication per ASTM A123. The weight of zinc coating shall be 100 percent of the requirements specified under "Weight of Coating" in ASTM A123, as applicable.

9. Manufacturer shall provide detailed written instructions for installation and maintenance of shim plates.

E. Silica Sand Epoxy Grout:

1. Epoxy-Resin System shall be of two component, solvent-free, moisture insensitive, epoxy resin system, 1:1 or 1:2 (B:A) ratio by volume. The material shall not contain asbestos.

2. Component A shall be a modified epoxy resin of the epichlorohydrin bisphenol A Type, containing suitable viscosity control agents. It shall not contain butyl glycidyl ether.

3. Component B shall be an ethylene-amine and an amine adduct combination containing suitable viscosity control agents and accelerators.

4. Properties:

a. Viscosity, 1,800 to 2,600 centipoises.

b. Pot Life, 30 to 38 minutes, minimum.

c. Compressive Properties, tested at 28 days in accordance with ASTM D695.

1) Compressive Strength, 12,000 psi, minimum.

2) Modulus of Elasticity in Compression, 4.5×10^5 psi, minimum.

d. Tensile Properties, tested at 14 days in accordance with ASTM D638.

1) Tensile Strength, 5,500 psi, minimum.

2) Modulus of Elasticity in Tension, 3.0 x 10^5 psi, minimum.

3) Elongation at Break, 1 to 2 percent.

e. Flexural Properties, tested at 14 days in accordance with ASTM D790.
1) Flexural Strength, 9,000 psi, minimum.

2) Tangent Modulus of Elasticity, 6.0 x 10^5 psi, minimum.

f. Shear Strength, tested at 14 days in accordance with ASTM D732, 5,000 psi, minimum.

g. Water Absorption, tested at 7 days in accordance with ASTM D570, 1 percent maximum.

h. Volume Resistivity, tested in accordance with ASTM D257, 1 x 1012 ohm-cm minimum.

i. Bond Strength, tested in accordance with ASTM C882, 2,000 psi.

j. Shrinkage: No shrinkage will be allowed

5. Silica Sand shall be graded standard sand in accordance with ASTM C778. Silica sand shall be oven-dried having no water moisture content.

6. Pull-out strength shall be as specified in Section 34 11 27, “Direct-Fixation Track Construction.”

2.02 OVERAGE

A. The Contractor shall turn over to the VTA any direct fixation fasteners, including whole assemblies and parts, which are remaining (overage) after the portion of the Work utilizing direct fixation fasteners has been accepted by the VTA. The remaining assemblies and parts shall be clearly marked "Overage" to distinguish this material from the spare parts material. The VTA shall determine the type and location of the marking so that all items are easily identifiable when installed. Overage shall be delivered to the Cerone Marshaling Yard, 3990 Zanker Road, San Jose.

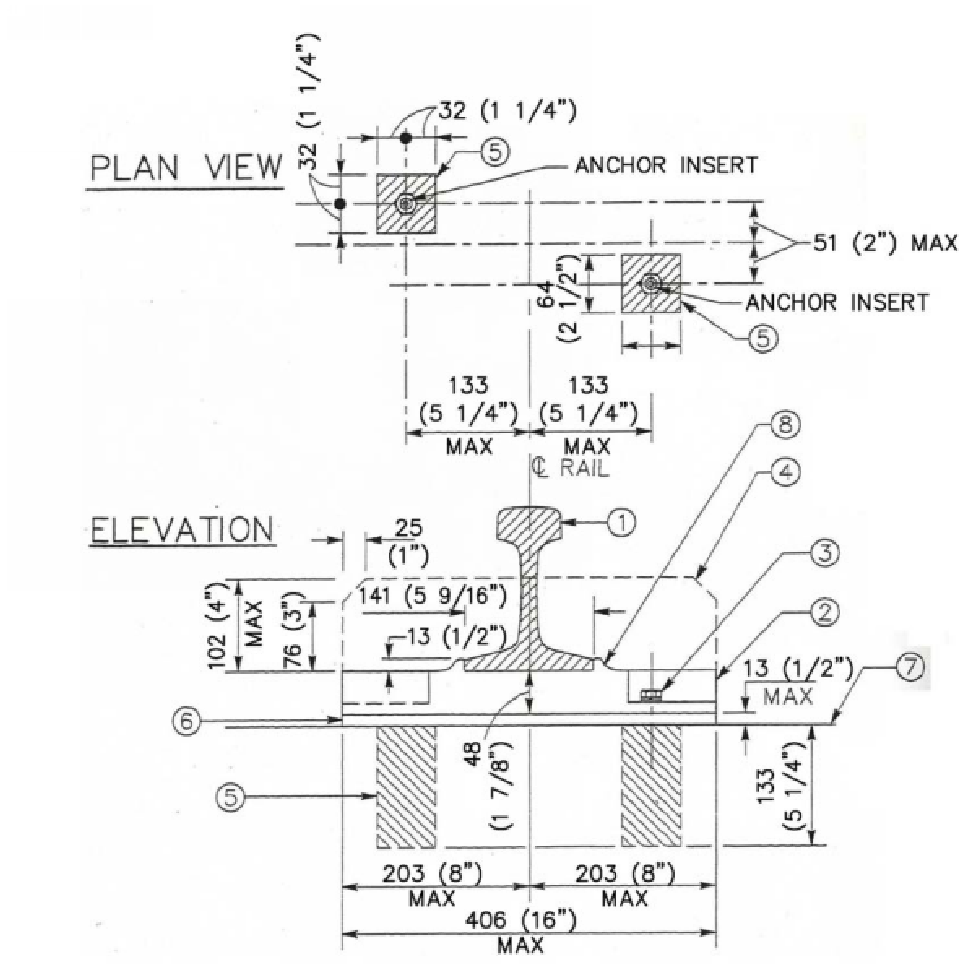
PART 3 – EXECUTION

3.01 DIRECT FIXATION FASTENERS

A. Direct fixation fasteners shall be installed as specified in Section 34 11 27, “Direct Fixation Track Construction.”

END OF SECTION 34 11 36

① 57 kg/m (115 RE) RAIL
② FASTENER BODY-GAUGE SIDE
③ ANCHOR BOLT
④ FASTENER ENVELOPE
⑤ ANCHOR INSERT ENVELOPE
⑥ SHIM PLATES – 3 mm (1/8 INCH) OR 10 mm (3/8 INCH)
⑦ CONCRETE TRACKBED
⑧ SHOULDER



NOTE: DIMENSIONS SHOWN ARE IN MM UNLESS OTHERWISE NOTED

FIGURE 1 FASTENER CLEARANCE ENVELOPE

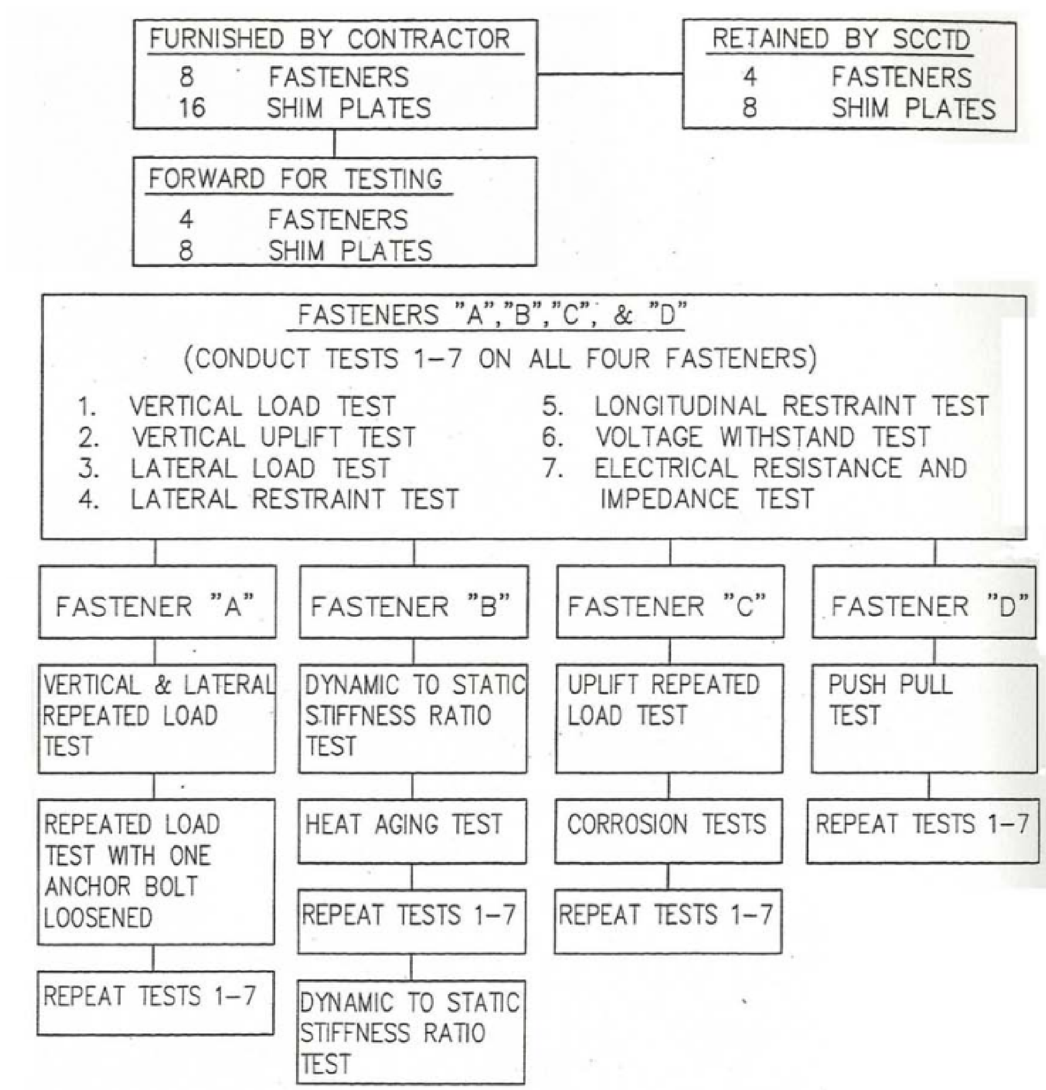


FIGURE 2 QUALIFICATION TESTING SEQUENCE

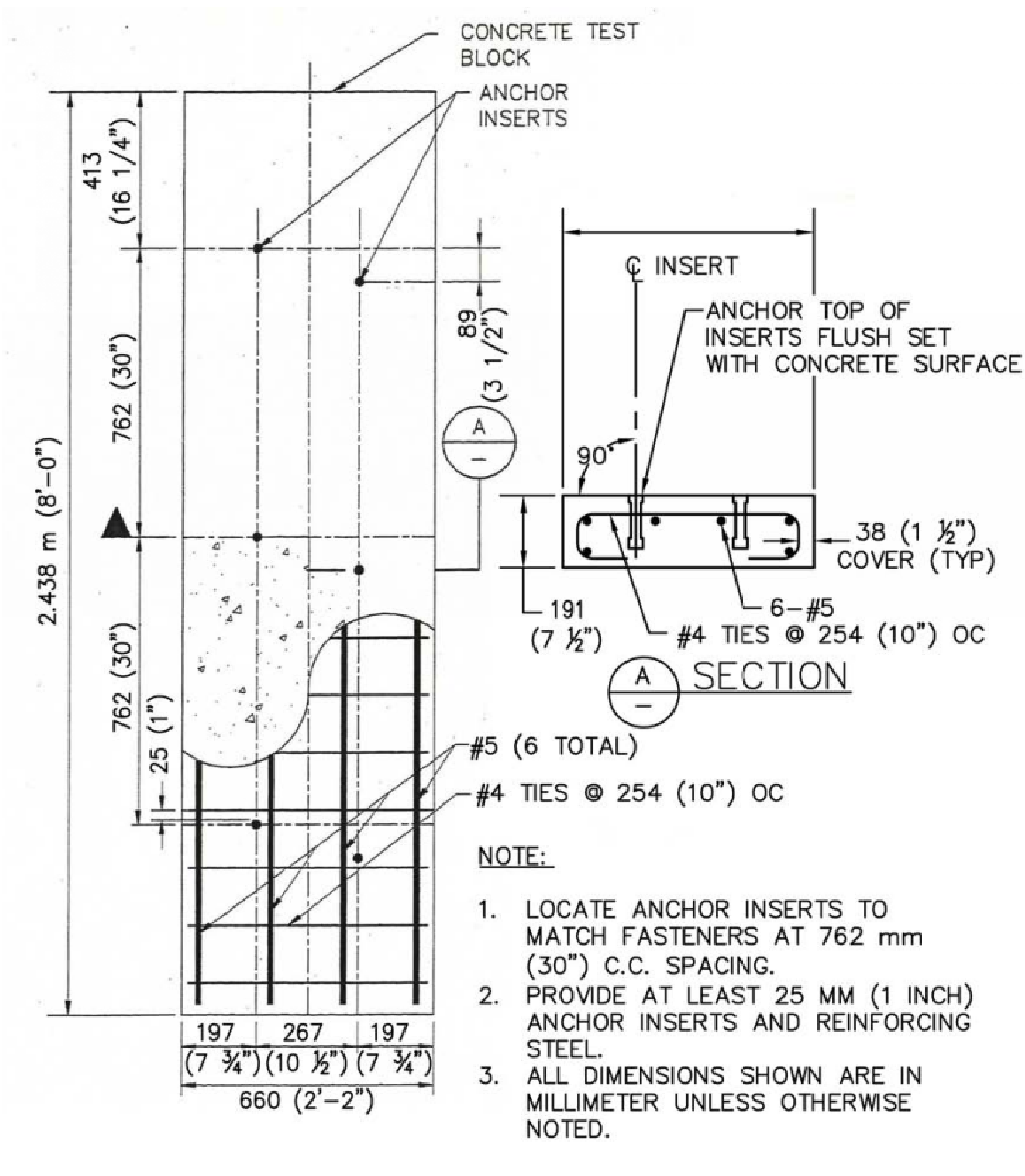


FIGURE 3 BLOCK FOR TESTING ANCHOR ASSEMBLIES

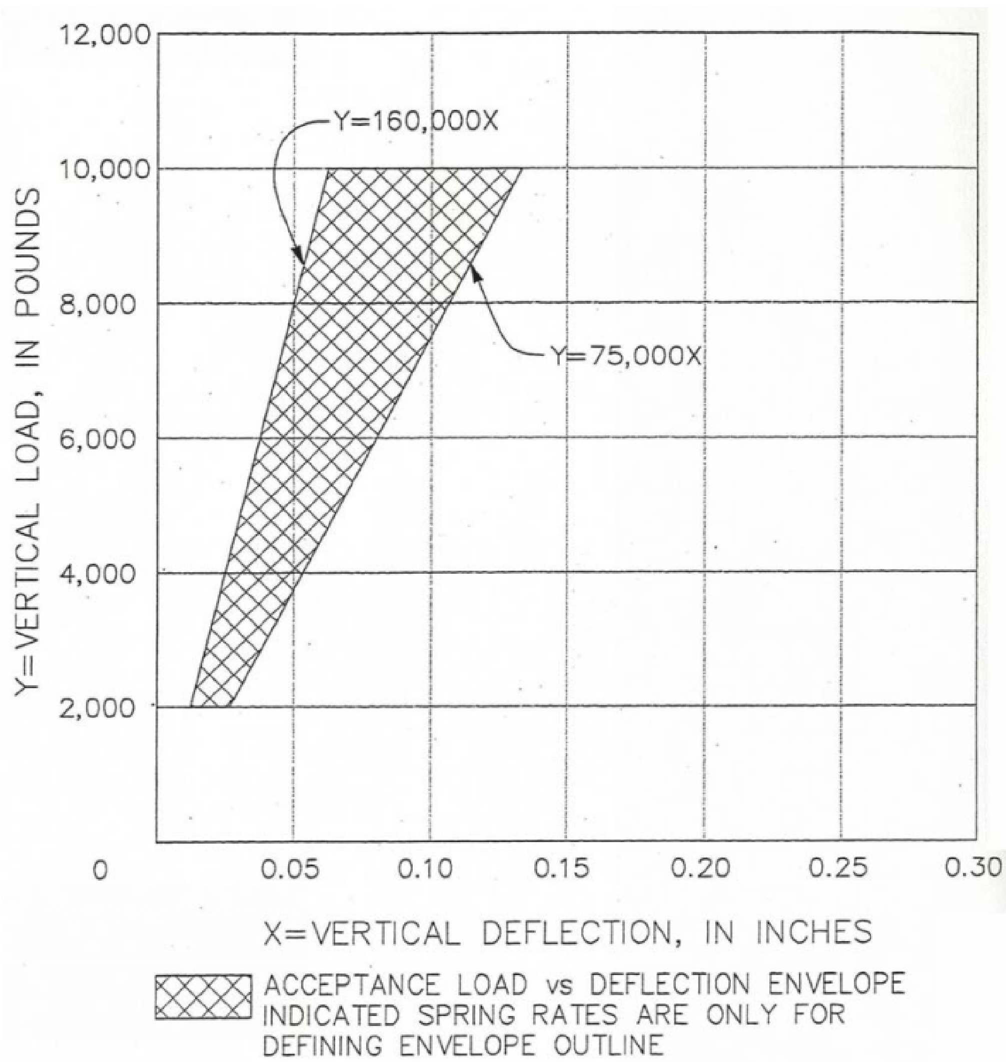


FIGURE 4 VERTICAL LOAD TEST ACCEPTANCE CRITERIA

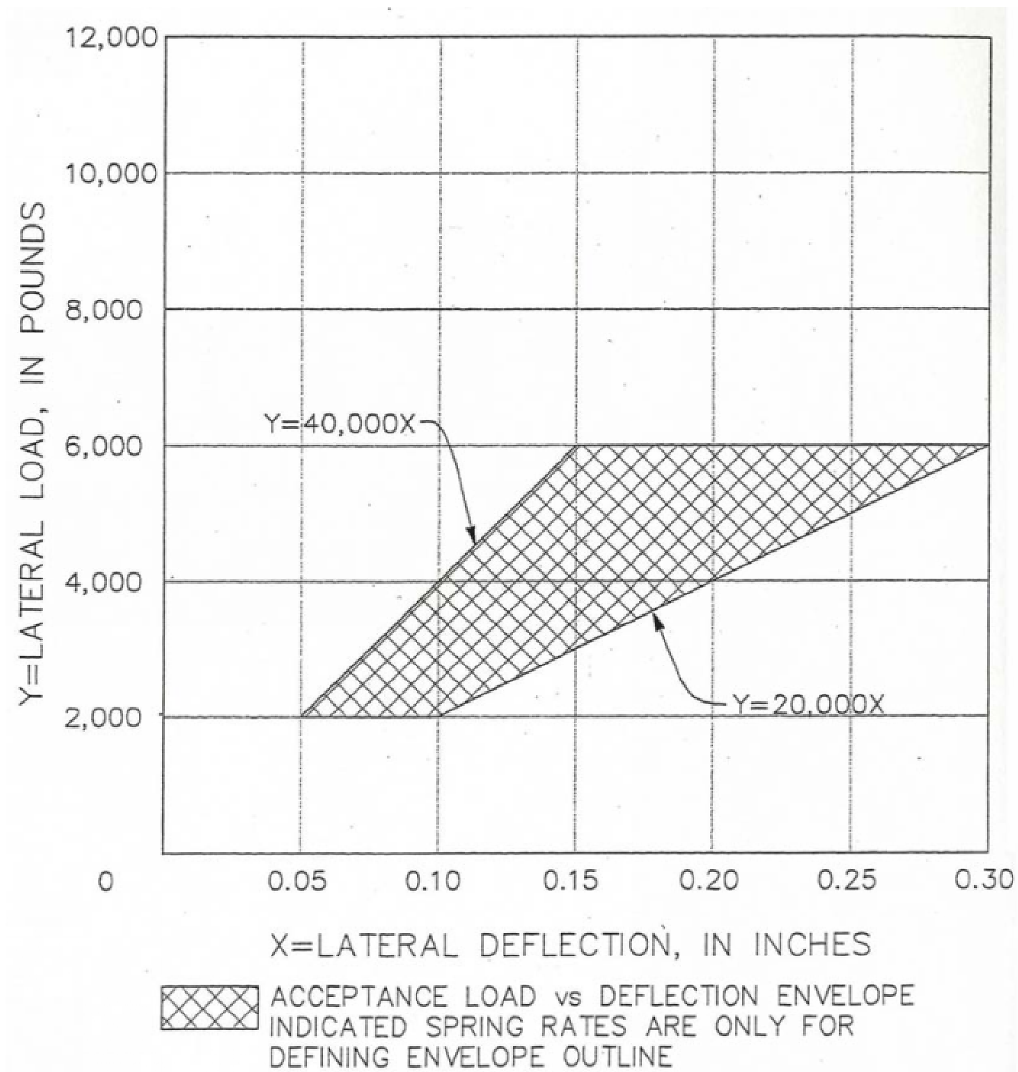


FIGURE 5 LATERAL LOAD TEST ACCEPTANCE CRITERIA

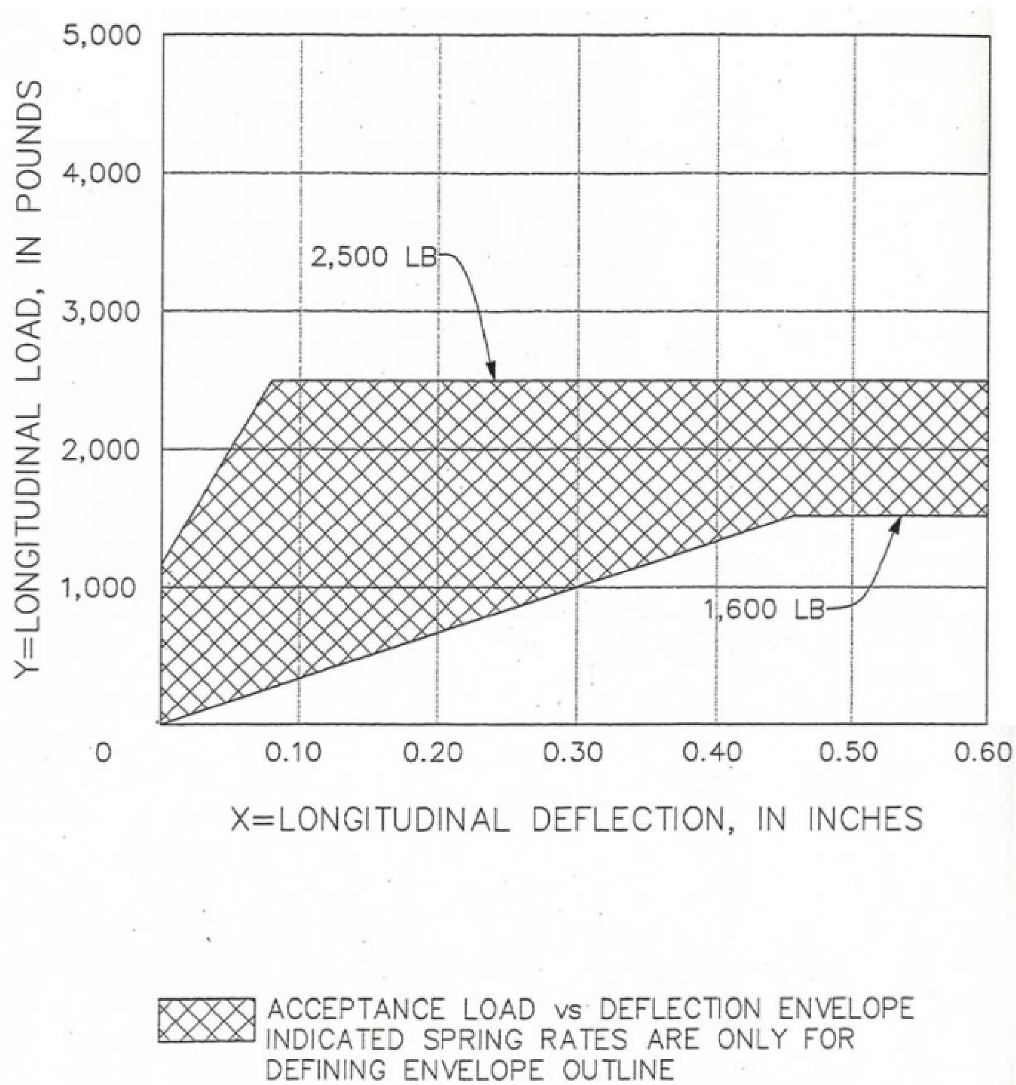


FIGURE 6 RESTRAINT TEST ACCEPTANCE CRITERIA

SECTION 34 11 40

TRACK-TO-EARTH RESISTANCE

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This Section includes requirements for minimum track-to-earth resistance and testing procedures to determine the resistance-to-earth characteristics of the running rails and restraining rails in tie and ballast, direct fixation, embedded, and special trackwork.

1.2 QUALIFICATIONS

A. All track-to-earth resistance testing and calculations shall be performed by a NACE certified Corrosion Technician under the supervision of a Corrosion Engineer. A Corrosion Technician is a NACE CP2 (CP Technician), CP3 (CP Technologist), or CP4 (CP Specialist). A Corrosion Engineer is a Registered Professional Corrosion Engineer or a NACE CP4 (CP Specialist) who has at least 5 years of experience performing the type of track-to-earth resistance testing described in this specification.

1.3 SUBMITTALS

A. Testing Group: The Contractor shall submit the identity, qualifications, and years of experience of the testing agency to be employed on the Contract. This submittal shall include full background data on the testing agency, including references to prior work or projects having requirements and/or complexities similar to that of this Contract. The names and experience of both the senior or management and field personnel to be employed on this project shall be included.

B. Testing Plan: The Contractor shall submit a detailed written description of the proposed testing techniques for preliminary approval by the VTA 45 calendar days prior to the scheduled date of testing. This submittal shall be sufficiently detailed to demonstrate how all requirements of this Section will be met. The VTA will observe initial field tests for each test method. After review of two separately recorded tests, including completed data and data sheets, for each test method, the Contractor will revise the testing plan as required and obtain written approval from VTA to proceed with the remainder of the testing. Following such approval, the testing techniques and data shall not be varied or changed without written approval from the VTA.

C. Instrumentation: The Contractor shall submit a list of instruments to be used for the electrical testing. This list shall include the manufacturer's name, model number, serial number, specification sheet, and calibration certificate for each instrument and shunt. Devices or procedures for making low-resistance contact with the rails shall be included.

D. Documentation: The Contractor shall submit a test data sheet showing the proposed format for test data documentation. Test data to be collected, along with the electrical measurements described in Part 3, shall include the date and time of the test; the test personnel; the location, including stationing and rail and track designation, of each test wire; reason for test (planned or re-test) and any corrective actions performed; the file and channel numbers when data loggers are used; a description of the weather conditions during the test; a description of any visual inspection conducted to find possible stray current paths; a description of any other testing performed to identify stray current issues; and notes regarding any unusual circumstances or suspected electrical interference during the test.

E. Testing Report: The Contractor shall submit a testing report that includes the test results, graphs of the data, calculations performed, and track-to-earth resistance measurement results. Graphs shall be provided for all data logger channels that are collected. Calculations shall be provided in a format that shows the progression of each calculation step shown in Part 3. Track-to-earth resistance measurement results shall be provided in units of ohms per 1,000 feet of single track and labeled as “pass” or “fail” per the applicable criterion for each type of trackwork. A description of, and photographs and findings from, any additional investigation or corrective action performed shall also be included.

1.4 SEQUENCING AND SCHEDULING

A. Testing shall be completed in two phases.

1. Method 1 testing shall be completed in a maximum of 1,000-foot sections of track or rail. Testing shall be performed as soon as all major construction work for that segment is completed, including final torquing of rail fastener anchor bolts, and installation of rail insulations and electrical bonds. The purpose of timing of this testing is to verify the electrical resistance quality of the track as the work proceeds.

2. Method 2 testing shall be completed after all work on the track and rails has been completed, after all signal and traction power wiring and equipment is installed in its final configuration, before revenue operation has begun, and before making the project alignment electrically continuous with other contracts or the existing rail system. Method 2 testing shall be completed in maximum increments of 2,000 feet. The purpose of this test is for final acceptance of the track-to-earth resistance for the entire alignment.

B. The Contractor will not be permitted to defer testing to consolidate the testing effort.

C. Method 2 testing shall be conducted before the project alignment is made electrically continuous with any other trackwork outside the project limits. Refer to Part 3 of this Section for additional requirements.

1.5 QUALITY PROGRAMS

A. The program per GC-47 "Quality Assurance Program" as modified by SC-33 “Modifications to General Conditions, GC-47 Quality Assurance” shall include the following:

1. The tests are to be performed by a company or agency employed by the Contractor and approved by the VTA. Once such a company or agency is approved, they shall not be discharged or otherwise replaced by the Contractor without the written approval of the VTA.

2. The testing company or agency proposed by the Contractor must be an independent firm regularly engaged in similar electrical testing for rail systems. The employees assigned to the project are to be personnel familiar with electrical testing procedures, electrical instrumentation, and general electrical networks. Personnel must be capable of modifying the procedures specified herein to suit actual field conditions, where required.

3. A minimum of three readings for Method 1 and ten readings for Method 2 shall be taken to determine an electrical constant or property and must be sufficient to assure that random factors due to human error in reading the instruments and transient disturbances in the electrical network have a negligible influence on the final results. The data shall be examined to see that removal of either the highest or lowest value will not alter the arithmetic average of the group by more than 3 percent. If the average is altered by more than 3 percent, one more set of data shall be taken and the results combined with the first set. If the average of the combined data is still altered by more than 3 percent by removal of the highest or lowest value, an unstable condition might exist, and the VTA shall be advised.

4. Installation and other Contractor-related conditions that result in lower than specified track-to-earth resistances shall be repaired and retested by the Contractor at no additional cost to the VTA.

1.6 SITE CONDITIONS

A. Prepare the site for testing by completing cleaning operations, as required, prior to commencement of testing.

1.7 REFERENCED SPECIFICATIONS, CODES AND STANDARDS

A. The WORK of this Section shall comply with the current editions of the codes and standards referenced in this specification, including the following:

1. ASTM — ASTM International
   a. G165 — Standard Practice for Determining Rail-to-Earth Resistance
2. NACE — NACE International
   a. TM0497 — Measurement Techniques Related to Criteria for Cathodic Protection on Underground or Submerged Metallic Piping Systems

1.8 MEASUREMENT AND PAYMENT

A. The contract lump sum price paid for Track-to-Earth Resistance Testing as shown on the Schedule of Quantities and Prices shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in both Phase 1 and Phase 2 testing as described in these Technical Specifications, and as directed by the VTA.

PART 2 - PRODUCTS

2.1 GENERAL

A. The Contractor shall provide all equipment and tools necessary to conduct testing in accordance with the approved test procedures.

B. All meters, gauges, shunts, and other measuring equipment shall be calibrated within 12 months of the date of each test. Equipment shall be recalibrated on a regular basis during the life of this Contract to continuously meet this requirement.

C. To the degree feasible, use the same testing equipment and field personnel for similar tests during the life of this Contract.

D. The test equipment listed in this Section represents the minimum standards. Instrumentation having equal or greater accuracy and resolution will be allowed, provided it is pre-approved by the VTA and meets the requirements of this Section.

2.2 VOLTMETERS AND DATA LOGGERS, DC

A. Method 1 test: Voltmeters shall be in accordance with ASTM G165.

B. Method 2 test: Fluke 2635A, 2638A, or approved equivalent shall be used.

1. A minimum of three recording digital voltmeters (data loggers) shall be used.

2. Recording voltmeters shall have a minimum of three channels and be capable of recording all three channels to memory at a rate of four channels per second.

3. Recording voltmeters shall have a minimum input impedance of 100 megohms for all scale ranges up to 3 volts, have a resolution to 1 microvolt, and be accurate to within 0.24% + 6 microvolts over the 12-month calibration cycle.

4. Recording voltmeters shall have typical scale ranges as follows:

0 to 90 millivolts

0 to 300 millivolts

0 to 3 volts

0 to 30 volts

2.3 SHUNTS

A. Current flow shall be measured using calibrated external shunts that are sized to meet the current required for the test.

2.4 DC POWER SOURCE

A. A portable DC power source shall be used to supply DC current to the rails. The DC power source shall be either batteries (such as car or marine batteries) or a regulated power source with a linear regulator to limit ripple to less than 0.25% of the nominal output voltage. Graphs of the recorded data shall be analyzed to determine whether the power supply ripple may need to be reduced even further.

B. Batteries shall be of sufficient size to supply the required current and maintain output voltage to within 10% of the initial voltage for the duration of the test.

C. The power source shall have a minimum nominal output voltage of 12 volts and a current capacity of 30 amperes. Higher voltages may be used in order to increase the accuracy of the measurements, consistent with safety considerations. The Contractor is responsible for safety during the testing, regardless of the voltage selected.

D. The power output shall be interrupted using a switch, relay, or current interrupter. Breaking the current by connecting and disconnecting clips or wire connections is not acceptable.

E. High-wattage resistors may be needed to limit the current when testing the rail resistance.

2.5 TEST WIRES AND CONNECTIONS

A. Single-conductor, stranded, copper wire shall be sized to suit the testing requirements. The wire insulation shall be rated for 600 V at a minimum. Provide sufficient length(s) of wire to establish test circuits. Wires shall be terminated as described in Part 3.

B. Test wires shall be checked daily for breaks in the insulation. Breaks shall be fixed prior to testing.

C. Provide serrated or pointed clamps or clips as required to make low-resistance contact through any rust that may be present on the rails.

D. Provide terminal boards, etc., as required to keep all wire connections insulated from each other and insulated from foreign objects and ground.

2.6 REFERENCE ELECTRODE

A. Reference electrodes shall be saturated copper-copper sulfate and shall be maintained in accordance with NACE TM0497.

B. If used on concrete, reference electrodes shall have a flat bottom and sufficient diameter to stand upright on their own. Provide wet sponges for contact with concrete surfaces.

2.7 DATA LOGGER SYNCHRONIZATION

A. Provide GPS-synchronized current interrupters or other approved means to trigger the data loggers within 1 millisecond accuracy when simultaneous measurements are taken for Method 2 tests.

2.8 MISCELLANEOUS TOOLS AND COMPONENTS

A. As required for making wire connections, splicing, etc.

PART 3 - EXECUTION

3.1 VISUAL INSPECTION

A. The trackwork shall be visually examined to ensure that there is no appreciable amount of debris, water, dirt, ballast, or other conductive material in electrical contact with the track or track components which could result in lowering of the effective track-to-earth resistance. The conditions and type of track section to be tested shall be recorded on the data sheets.

B. All test data and calculations for each track section tested shall be furnished to the VTA for review and approval. Test results shall include a summary tabulation of the calculated track-to-earth resistance values including field data and calculations for each section tested. The test data sheets and summary tabulation shall include information on track construction status and the general level of cleanliness at the time of testing.

3.2 GENERAL TEST METHODS

A. Electrical connections and splices shall be made using appropriate banana plugs, crimped connections, screw terminals, soldered joints, or bolted connections. Alligator clips may be used at the field end of wires, provided they are kept off the ground and prevented from contacting other wires or objects. Multiple alligator clips shall not be connected together. Alligator clips shall not be attached to objects other than conductors and terminals.

B. Wires and their connections shall be arranged in a neat and orderly manner. Stray wire strands shall be removed, and insulation shall be applied as required to prevent contact between conductors and between conductors and foreign objects.

C. For tests using multiple channels of a data logger, test boards shall be made in advance to terminate the leads for each channel at an appropriate terminal block to which the field wires can be connected. Wires shall be labeled.

D. Wire connections to the rails shall be made using an approved method that minimizes the effect of rust on the rail surface and provides a low-resistance (less than 1 ohm) contact. Serrated or pointed clips or probes may be used, or the rust may be filed or sanded from the rail. These devices and procedures shall not damage the rail.

E. Reference cells shall be placed in contact with soil or concrete as appropriate. Reference cells shall be used in accordance with NACE TM0497. Where reference cells are placed on concrete, a water-saturated sponge shall be used to make contact between the reference cell and the concrete surface. Concrete surfaces and dry soil shall be wetted. Reference cells shall be checked before and after each test; if found to have fallen over or lost moisture at the contact zone, the test shall be repeated.

3.3 TRACKWORK ELECTRICAL TESTS

A. The following tests shall be conducted on all trackwork with the exception of special trackwork areas. There are two basic methods for determining the resistance-to-earth characteristics of a given track section. Method 1 shall be used for discrete, electrically separate sections of track, where running rail insulating joints have been installed or where track sections adjacent to the particular section under test have not yet been installed. Method 2 shall be used for testing track sections which are electrically and physically interconnected to adjacent track sections. The purpose of this Section is to establish the basic electrical test connections for track-to-earth resistance measurements and present the appropriate resistance formulae. Note that variations in actual track configurations to be tested will occur.

B. Both test methods shall be employed before the running rails in the project alignment are made electrically continuous with those of other contracts or the existing rail system. Although Method 2 is used for electrically interconnected track sections, it cannot be used where any given test segment would be less than 10% of the length of the total interconnected track length. Method 2 also cannot be used in the presence of any external electrical interference, including but not limited to the following:

1. Propulsion return current on any portion of the rail system that is electrically continuous with the section being tested. This includes return current from stopped trains with active lighting, HVAC, etc., loads.

2. Substation imbalance current through the running rails when substations are live but unloaded.

3. Power- or audio-frequency or coded track circuit transmitters.

4. Cab signal or speed code transmitters.

5. Welding operations.

C. Method 1 shall be used for electrically separate track sections. All testing for Method 1 shall be in accordance with ASTM G165, with the following exceptions:

1. The acceptance criteria shall be as stated in this Section.

D. Method 2 shall be used for electrically interconnected track sections. Refer to Figure 1 for an electrical schematic of the test procedure. Additional testing may be required to pinpoint locations causing low track-to-earth resistance.

1. Measure resistance of rails to be used as a current measurement shunt in subsequent steps. Use a test current of at least 30 amperes. Resistance measurements shall be performed using a four-wire ("Kelvin") method. The potential leads shall be spaced at the same spacing as will be used for the current measurements in subsequent steps. The current leads shall be connected to the rail at least 5 feet outside the potential leads. Rail resistance can vary by up to roughly 50% over the course of a day due to temperature changes. The change in rail resistance due to temperature changes, and the effect of different grades of rail that may be installed on the project, shall be accounted for by additional resistance tests as required.

2. Establish a cross bond between Rail A and Rail B at the location shown to equalize the current distribution between rails and allow all current flowing back to the current source to pass through the rail shunt *e*. If an insulating joint is located on Rail A between the bond and rail shunt *a*, install another bond (not shown in the schematic) across Rail A and Rail B at the insulating joint on the test section side of the insulating joint. An insulating joint should not exist between the current source and the test section on Rail B. There shall not be any insulating joints within the test section or rail shunts *a*, *b*, *c*, *d*, or *e*.

3. Set up track-to-earth potential measurements V_{g1}, V_{g2}, and V_{g3} using a connection to the reinforcement in the concrete structure supporting the tracks (if present) or using reference electrodes in the soil adjacent to or below the track.

4. Set up the first recording voltmeter to simultaneously record the battery current output through a shunt, the battery voltage, voltage drop across rail shunt *e* (E_e), and track-to-earth potential at rail shunt *e* (V_{g3}). Use the smallest scale possible for each channel so that the meter does not go out of range.

5. Set up the second recording voltmeter to simultaneously record E_a, E_b, and V_{g1}. Use the smallest scale possible for each channel so that the meter does not go out of range.

6. Set up the third recording voltmeter to simultaneously record E_c, E_d, and V_{g2}. Use the smallest scale possible for each channel so that the meter does not go out of range.

7. Establish a circuit current (I) between the track system and a low-resistance ground contact. The current (I) should be of sufficient magnitude to produce a current flow greater than 1 ampere in the 50- to 100-foot rail shunts in the test section. The current circuit shall not be connected to ground through the same connection as is used for V_{g3}.

8. Start all three recording voltmeters at the same time. Readings shall be synchronized within 1 millisecond using GPS current interrupters as a trigger or using other approved means.

9. Cycle the current source "on" and "off" so that each records a minimum of 10 readings when the current is "on" and 10 readings when the current is "off." Repeat the "on/off" cycle 10 times for a minimum of 200 data points.

10. Measure the length of the test section using a distance measuring wheel.

11. Calculate the track-to-earth resistance per the procedure below.

E. The calculations associated with Method 2 shall be done as follows.

1. Calculate the current in each rail using the measured voltage drop and rail resistance at locations *a*, *b*, *c*, *d*, and *e*. Use the difference in voltage drop between the "on" and "off" measurements at these locations so that any steady-state current from other sources is canceled out:

$\Delta I_a = \frac{\Delta E_a}{R_{rail}}$ = Test current in Rail A at location 1.

$\Delta I_b = \frac{\Delta E_b}{R_{rail}}$ = Test current in Rail B at location 1.

$\Delta I_c = \frac{\Delta E_c}{R_{rail}}$ = Test current in Rail A at location 2.

$\Delta I_d = \frac{\Delta E_d}{R_{rail}}$ = Test current in Rail B at location 2.

$\Delta I_1 = \Delta I_a + \Delta I_b$ = Total test current at location 1.

$\Delta I_2 = \Delta I_c + \Delta I_d$ = Total test current at location 2.

2. Calculate the leakage current from the test section by taking the difference in measured current from one end of the test section to the other:

$\Delta I_{leakage} = \Delta I_1 - \Delta I_2$ = Leakage current out of test section.

3. Calculate the average track-to-earth resistance of the test section using the leakage current and the average rail voltage rise due to the application of the test current:

$\Delta V_{avg} = \frac{\Delta V_{g1} + \Delta V_{g2}}{2}$ = Average rail voltage rise.

$R_{TE} = \frac{\Delta V_{avg}}{\Delta I_{leakage}}$ = Track-to-earth resistance of tested section.

4. Calculate the track-to-earth resistance normalized to a 1,000-foot length of single track (two rails).

$\bar{r} = (R_{TE})(L)$ = The track-to-earth resistance for 1,000 feet of track consisting of two rails (Ω/1,000 ft).

where R_{TE} = The average track-to-earth resistance for the test section (Ω).

L = The length of the test section in thousands of feet.

3.4 SPECIAL TRACKWORK ELECTRICAL TESTS

A. Electrically separate track sections. All testing for Method 1 shall be in accordance with ASTM G165 with the following exceptions:

1. The acceptance criteria shall be as stated in this Section.

B. Special trackwork having track-to-earth resistance values less than the minimum acceptance criteria shall be subdivided into smaller test units, as necessary, by removal of temporary bond cables installed for the base measurements. Troubleshooting tests shall be performed by the Contractor to determine the specific reason(s) for the unacceptable resistances and appropriate remedial action should be recommended.

3.5 ACCEPTANCE CRITERIA

A. The following are the minimum acceptable track-to-earth resistances:

1. Ballasted track construction (including street crossings): 203 Ω/1,000 feet (62 kΩ/m) per track (two rails)

2. Embedded track construction: 105 Ω/1,000 feet (32 kΩ/m) per track (two rails)

3. Direct fixation construction: 105 Ω/1,000 feet (32 kΩ/m) per track (two rails)

4. Crossover turnouts should meet the same track-to-earth resistance of adjacent trackwork.

5. Trackwork with restraining rail (three rails bonded in parallel):

    a. Ballasted: 135 Ω/1,000 feet (41 kΩ/m) per track (three rails)

    b. Embedded: 69 Ω/1,000 feet (21 kΩ/m) per track (three rails)

    c. Direct fixation: 69 Ω/1,000 feet (21 kΩ/m) per track (three rails)

B. If the test results show that any section of track work or restraining rail fails to meet acceptance criteria, the Contractor's testing agency shall check all instrumentation setups; verify that the equipment is operating properly; inspect the section under test for installation deficiencies; and correct any problems detected, including cleaning the trackwork, as may be required to assure proper data collection. Following this, the tests shall be repeated as soon as possible. If the retest results in failure to meet acceptance criteria, notify the VTA and provide labor and equipment to determine the location and cause for failure. If the cause is determined to be failure of the Contractor to comply with Contract requirements, correct the problem(s) at no additional expense to the VTA. If the problem is determined to be outside of the control of the Contractor, immediately report the situation to the VTA for determination of the appropriate course of action.

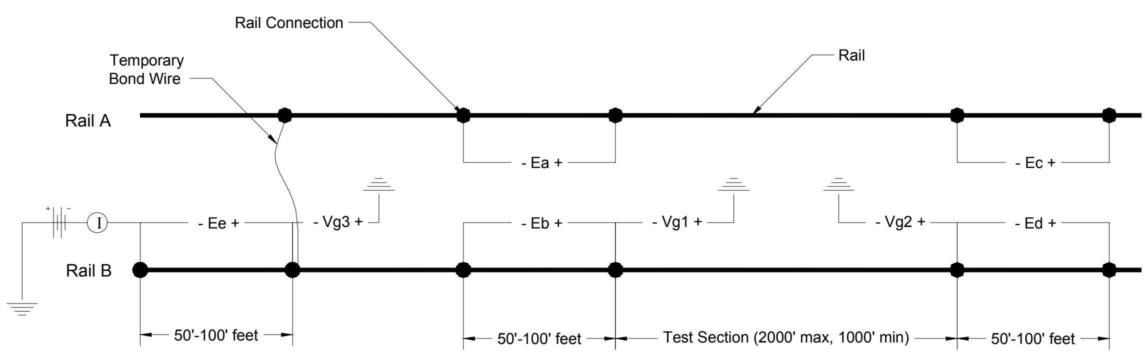


Figure 1. Method 2 for electrically continuous track sections

END OF SECTION 34 11 40

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SECTION 34 11 43

PRESSURE RAIL WELDING

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for pressure rail welding. Pressure welding may be performed using either a portable electric flash-butt welding plant or a mobile welding machine designed for rail welding and approved by VTA.

1.02 REFERENCED STANDARDS

A. American Railway Engineering and Maintenance of Way Association (AREMA): Manual for Railway Engineering, Vol. I, Chapter 4, Specification for Fabrication of Continuous Welded Rail (CWR) and Specification for Thermite Welding - Rail Joints.

B. American Society for Testing and Materials (ASTM):

1. E18 Standard Test Methods for Rockwell Hardness of Metallic Materials.
2. E94 Standard Guide for Radiographic Examination.
3. E164 Standard Practice for Ultrasonic Contact Examination of Weldments.
4. E709 Standard Guide for Magnetic Particle Examination.

1.03 SUBMITTALS

A. The Contractor shall make all submittals in accordance with the requirements of Special Conditions SC-6 and SC-51 and as specified herein.

B. Pressure Welds:

1. Submit written description of welding ability, facilities and equipment to be used, qualifications and experience of welding foreman, welding machine operator and lead grinder and list of similar completed projects.
2. Before pressure welding of rail, submit a detailed description of proposed pressure welding machine and calibration methods, method and procedure of handling and preparation of rails for pressure welding; method and procedure for clamping, alignment, flash welding cycle, method and results of weld upset shearing and protection of weld alignment as rail is removed from welding machine. Method of handling rail strings from welding machine including alignment verifications, rough grinding, on-site preliminary testing of each weld, handling of strings to stockpile location and method and arrangement of stockpiling as CWR strings are produced shall also be provided.
3. Contractor shall prepare and submit detailed schedule of lengths of rail strings to be fabricated including designation by route name, track designation, beginning and ending stations for each string and identification of left hand or right-hand rail (as determined by

facing in the direction of increasing engineering station). Exact system of marking string designations on the rail at the time of production shall also be provided. CWR string schedule shall indicate which strings or which portions of strings will be standard rail and premium rail. When strings are to be cut in the field, the schedule shall indicate locations of proposed cuts. The CWR schedule shall be designed to minimize the number of closure joints and shall minimize the generation of short rails.

4. Submit details and example of methods of identifying pressure rail welds on rail strings at the time of production.

5. Submit details of equipment and procedure proposed for straightening welds when required. Submittal shall include reference data relating to where the proposed straightening equipment and method were previously successfully used.

6. Pressure Weld Production Report: Submit sample copy of form to be used by Contractor to record production of each pressure rail weld made. Proposed report form shall include complete weld string, weld number and rail heat numbers on each side of weld and shall otherwise correlate with Welding Machine Performance report and CWR String Schedule plan developed by Contractor. Sample copy of a thermite weld production report is attached to Section 34 11 44, "Thermite Rail Welding," identifying the format and content acceptable to VTA.

7. Welding Machine Performance: Submit pressure welding machine performance standards provided by welding machine manufacturer. Provide sample form of welding machine performance report which must provide record of platen movement and current impulses. Record of machine performance for each weld shall include date, rail string and weld number corresponding to the number indicated on the rail string and on the weld test report. Sample form shall include identification of thresholds for rejection of weld due to machine failure.

8. Weld Testing Agency: Submit copy of Contractor agreement with Weld Testing Agency as specified hereinafter. In Article 3.09, “Testing Agency Agreement”.

1.04 DEMONSTRATION AND SAMPLE PRESSURE WELDS

A. General: Contractor shall demonstrate welding ability and qualifications of welding personnel by the performance of pressure rail weld samples. VTA shall be notified at least 2 days before the making of demonstration and sample welds. A representative of VTA and an inspector of the Testing Agency shall be present during the time the demonstration and sample welds or subsequent rewelds are being performed.

1. Qualification of Contractor Welding Personnel: Contractor shall provide names and individual qualification of personnel proposed for track welding and weld grinding indicating number of years of experience, previous rail welding jobs performed for this or other railroad contractors and levels of experience and/or certification. Submittal shall include copy of certification provided by authorized representative of the welding machine manufacturer proposed by Contractor for use on this Project. Contractors who do not have qualified and certified welding machine operators shall be given opportunity to obtain certification and demonstrate such competence.

2. Pressure Weld and Demonstration Samples: Before production welding and at Contractor's expense, a minimum of 6 sample pressure rail welds shall be made using the welding machine and the procedures proposed in the manufacturer's instructions. Two

sample welds shall be made for each rail section and rail classification to be used in the Project. Two welds shall be standard rail to standard rail, 2 welds shall be premium rail to premium rail and 2 welds shall be standard rail to premium rail. Welds shall be made by qualified personnel proposed by Contractor.

3. Demonstration and sample welds shall be cut out of rails to be used to 35.4 inch in length and otherwise prepared according to Contractor's proposed pressure welding procedures. Each of the welds will be visually inspected and tested by the technician of the independent Testing Agency proposed by Contractor at the Worksite at the time of production according to the testing requirements for rail weld straightness, magnetic particle test and ultrasonic test. If all sample welds are found to meet these acceptance criteria, and other requirements of these technical specifications relative to pressure rail welding are approved, VTA may grant conditional approval to begin production pressure rail welding. Such conditional approval, if given, shall not relieve Contractor from compliance with the requirements of these technical specifications if Contractor elects to begin production welding. Final acceptance of demonstration and sample welds shall be subject to satisfactory completion of the additional weld tests specified in Article 1.05, "Testing of Demonstration and Sample Welds."

4. When the welding machine is returned to production after malfunctioning or when the welding crew is replaced, additional sample welds shall be performed in accordance with paragraphs 2 and 3 above. Acceptance of the welding machine or new crew shall be made after additional demonstration and sample welds satisfy the requirements of the weld tests specified in Article 1.05, "Testing of Demonstration and Sample Welds."

1.05 TESTING OF DEMONSTRATION AND SAMPLE WELDS

A. General: Sample welds for additional testing shall conform to the grinding and alignment tolerances specified in Article 3.02, "Rail Welding Quality Assurance," and Article 3.03, Pressure Rail Weld Finishing Requirements," herein before performing the following tests. In addition to the pressure rail weld testing requirements specified in Article 1.06, "Pressure Rail Welding Quality Assurance," and Article 1.07, "Pressure Weld Hardness Tests," the following qualification and acceptance tests will be performed on all of the sample welds:

1. Test weld shall be visually examined for cracks.

2. Weld hardness test, measured on the head of the rail across the center of the weld, shall show that the hardness of the weld shall be equal to the average Brinell hardness of the 2 rails joined with a permissible tolerance of +/- 20 Brinell points.

B. Each of the sample welds provided by Contractor shall be examined for internal cleanliness as follows:

1. Radiographic Examination: Sample welds shall be ground smooth to within 5 mils of the parent rail section and radiographically tested with a minimum of 4 exposures: one through the head, one through the web and one through each of the 2 flanges. Radiography shall be performed in accordance with ASTM E94. Radiographic film shall be Type 1 and Type 2. Exposed film density shall be within the range of 1.5 to 3.8. The film and certified tests reports shall be forwarded to VTA for approval.

1.06 PRESSURE RAIL WELDING QUALITY CONTROL

A. Inspect pressure welds in accordance with AREMA recommended practices and in accordance with these technical specifications and furnish test results to VTA.

B. Welds not meeting the requirements specified in Article 3.06, "Location of Pressure Rail Welds," are not acceptable and shall be rejected, cut out, and replaced with acceptable welds. Defective pressure welds shall be repaired or replaced as specified in Article 3.08, "Repair of Defective Welds."

C. Each pressure rail weld shall be visually inspected for surface and alignment conformance and shall be hand tested ultrasonically and by dry powder magnetic particle method in the field for defects after the rail has been laid in track and is track is within 1 in. of final surface and final alignment. Testing shall be performed by a qualified technician of the weld Testing Agency acceptable to VTA before final acceptance of the track construction.

1. Inspection of pressure rail welds by the dry powder magnetic particle method shall be in accordance with ASTM E709.

2. Ultrasonic test equipment shall be capable of detecting a 47 mils discontinuity 6-1/2 in. below top of rail. Ultrasonic inspection of welds shall be performed in accordance with ASTM E164. Weld Testing Agency shall develop an ultrasonic testing procedure which shall indicate incompletely fused welds. The testing procedure shall be submitted to VTA. Welds shall be inspected in accordance with accepted procedure and shall be visually inspected for surface cracks. Testing shall not be performed until weld has cooled to ambient temperature.

3. Inspection agency shall furnish an ultrasonic test report form that shall record 20 inspected welds per 8.5 inch x 11 inch sheet. The form shall include the location of the weld in track, the results of the ultrasonic inspection including the size of defects found in the head, web or base of rail; the results of visual inspection; recommendation for correcting welds found defective, name of inspector and other information needed. The form shall be subject to acceptance by VTA.

4. Welds found defective shall be repaired as specified in Article 3.08, "Repair of Defective Welds."

5. VTA may require Contractor to perform Brinell hardness test in accordance with ASTM guidelines as needed if the condition of pressure rail welds relative to hardness is uncertain. Brinell hardness of rail welds shall be measured and compared to the parent metal.

1.07 PRESSURE RAIL WELDING HARDNESS TESTS

A. General: Each of the demonstration pressure rail weld shall be tested for rail weld hardness by the Testing Agency before final acceptance of the demonstration welds.

1. Testing Agency shall perform the hardness tests specified and deliver test reports to VTA to allow 5 working days for review and appropriate action before final acceptance of the pressure rail welding demonstration and sample welds.

2. Weld hardness and testing of samples shall be performed at no additional expense to VTA.

B. Weld Hardness Samples and Tests:

1. Each demonstration pressure rail weld shall be tested for Rockwell hardness in accordance with ASTM E18 using a 338 pound (1.5 kN) diamond spheroconical penetrator in 1/8 inch increments longitudinally, transversely and vertically for a distance of 5-7/8 inch starting from the hardened end of the rail.

2. The hardness number and location shall be recorded.

3. After the hardness test has been performed, one sample shall be sectioned longitudinally for 12 inches along the centerline of one rail and the other sample shall be sectioned transversely 1/2 inch from the end of one rail. Both cross sections shall be etched to facilitate the observation of the hardness pattern.

4. The Rockwell hardness number shall not be less than 29.5C or more than 37.0C when measured at a point on the centerline of the rail head 1/2 inch from the rail end.

   a. The hardness shall decrease uniformly from the end of the rail to the hardness of the untreated rail in a distance of not less than 2 inch.

   b. The hardness pattern shall be uniform across the top surface of the rail head.

C. If VTA determines that the hardness of rail or welds is not within these technical specifications, Contractor shall measure additional Brinell hardness of the rail welds to be compared to the parent metal.

1.08 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 – PRODUCTS

2.01 WELD MATERIALS

A. Weld materials shall conform to Contractor's pressure weld submittals approved by VTA. Once approved, Contractor shall not change pressure welding machine, welding foreman, welding machine operator or lead grinder without resubmittal and subsequent approval of the new machine or personnel by VTA.

PART 3 – EXECUTION

3.01 PREPARATORY WORK FOR WELDS

A. Immediately before pressure rail welding, each rail end shall be wire brushed or ground as necessary to remove mill scale, oil, or dirt which might hinder the flow of electric current. Rail areas in contact with electrodes shall be ground to remove mill scale and raised rail brands.

B. Rail Straightness: Contractor shall check for end straightness before welding. Both ends and tops of rails shall be straight edged using a 36 in. metal straightedge, and deviations from straight shall be measured with a metal taper gauge. Rails which are at or exceed the tolerances in AREMA Manual, Chapter 4, Part 2, Section 2.1, Article 2.1.13 shall be straightened or cropped by Contractor.

C. All rails for welding by Contractor shall be oriented in the same direction such that rail brands face the field side or outside of the track and rail stamping is oriented to the gauge side of the track being constructed.

3.02 RAIL WELDING QUALITY ASSURANCE

A. Mismatched, nicked, damaged or jagged rail ends shall be either sawed or cut with an abrasive rail cutter.

B. Alignment of rails to be welded shall be at the head of the rail. Alternative alignment methods shall be used only upon approval by VTA.

1. Vertical alignment shall provide for a flat running surface. Differences of height of the rail shall be corrected in the base.

2. Horizontal alignment shall be accomplished in such a manner that any difference in the width of heads of rails shall be divided equally on both sides of the head. Where the difference, when divided by 2, exceeds 0.04 inches the gauge side shall be aligned flush allowing differences in the width of heads to occur on the field side.

3. Horizontal offsets shall not exceed 0.04 inches at the head or 1/8 in. at the base.

C. Rails shall have scale removed down to bright metal in areas where welding current-carrying electrodes contact rail. Weld and adjacent rail for a distance beyond the electrodes shall not be acceptable when in areas of electrode contact there is not more than 95 percent of mill scale removed. Examine electrode contact areas for evidence of electrode burns. When metal is displaced or when oxidized areas exhibit checks or small cracks, welds will not be acceptable and the rail shall be cut back clear of electrode burns.

D. Welds shall be forged to point of refusal to further plastic deformation and shall have a minimum upset of 1/2 in. with 5/8 in. as standard.

E. When flashing on electric-flash butt welds is interrupted because of malfunction or external reason, with less than 1/2 in. of flashing distance remaining before upset, rails shall be reclamped in the machine and flashing initiated again.

F. Defective welds shall be cut by saw or by an abrasive rail cutter. Torch cutting on rail ends to be welded is not acceptable.

3.03 PRESSURE RAIL WELD FINISHING REQUIREMENTS

A. Surface Misalignment Tolerance:

1. Combined vertical offset and crown camber shall not exceed 1:300, to a maximum of 0.06 inches at ambient temperature in accordance with AREMA Specification.

2. Welds displaying dip camber in accordance with AREMA Specification will not be acceptable.

B. Gauge Misalignment Tolerance: Combined horizontal offset and horizontal kink camber shall not exceed 1:300, to a maximum of 0.06 inches at ambient temperature in accordance with AREMA Specification.

C. A finishing deviation of the parent section of rail head surface shall not exceed + 0.01 inches to – 0.

D. Sides of rail head weld shall be finished to +/- 0.01 inches of parent section. Top and bottom of rail base shall be finished to within 0.01 inches of lowest rail.

E. Web zone, including underside of head, web, and both fillets on each side, shall be finished to within 1/8 in. of parent contour but shall not be deeper than the parent section. Finishing shall eliminate cracks.

F. Notches created by offset conditions, twisted or misshaped rails shall be eliminated by grinding to blend variations.

G. Fins on weld due to grinding shall be removed before testing.

H. Whenever possible, grinding shall be accomplished immediately following welding at an elevated temperature. When grinding must be done at ambient temperature, avoid grinding burns and metallurgical damage.

I. Finish grinding on running surface and gauge face of rail head shall be accomplished within 23.6 in. of either side of the center of the pressure rail weld.

J. Failure of Contractor to conform to these requirements will result in a work stoppage issued by VTA and removal of applicable items of work from progress payments until the work is in compliance with these requirements

3.04 INSPECTION AND TESTING OF WELDS

A. General: Magnetic particle and ultrasonic inspection and testing of pressure rail welds shall be performed by the Testing Agency. Final acceptance testing of pressure rail welds shall not be conducted until the track constructed with CWR is within 1 in. of final surface and alignment.

B. Inspect welds in accordance with Article 1.06, "Pressure Rail Welding Quality Control," and AREMA Recommended Practices. Test results shall be furnished to the VTA within 5 working days.

C. Defective welds shall be repaired as specified in Article 3.07, "Defective Welds."

3.05 IDENTIFYING PRESSURE RAIL WELDS

A. Each pressure rail weld shall be identified in the field at the time the weld is made in 2 in. high letters and numbers providing the string number and sequential weld number. This information shall be painted on the gauge side of the rail web with permanent paint.

B. Upon completion of each pressure rail weld string, at the time the string is made, Pressure Rail Weld Production Report shall be prepared in the field by Contractor's welder and shall be delivered to VTA documenting production of each string. Included shall be the string number, sequence number assigned to each weld and the heat numbers of rail on each side of the weld.

C. The location of each pressure rail weld placed in track indicated in engineering stationing shall include the weld string number, the pressure rail weld number, the track designation and left or right rail for which the string was produced per Contractor's Rail String Schedule shall be provided by separate report after the CWR is laid in track and is within 1 in. of final surface and alignment.

D. Failure by Contractor to conform to these requirements will result in a work stoppage issued by VTA and removal of applicable items of work from progress payments until the work is in compliance with these requirements

3.06 LOCATION OF PRESSURE RAIL WELDS

A. Final location of pressure rail welds in track shall allow not less than 2 in. from edge of any steel rail plate to the edge of the pressure rail weld. Contractor shall adjust location of pressure rail weld in track as necessary to avoid pressure rail weld occurring closer than 2 in. to a steel rail plate. Adjustment of location of pressure rail welds to accomplish proper clearance to steel rail plates shall be included in the items of work to which they apply.

3.07 DEFECTIVE WELDS

A. Pressure rail welds which fail to conform to straightness, alignment or grinding tolerances shall be deemed defective welds and shall be subject to removal and replacement per defective welds when tested in accordance with the magnetic particle method and ultrasonic test procedures in these technical specifications shall be determined as follows:

1. Welds showing a response at any level that is identified as a crack or lack of fusion will not be acceptable.

2. Welds showing a response that is less than 50 percent of the primary reference level will be acceptable.

3. Welds showing a response greater than 50 percent but that do not exceed primary reference level are acceptable, provided that all of the following apply:

   a. The defects are evaluated as slag or porosity.

   b. The largest defect does not exceed 0.18 inch in its largest dimension.

   c. The total area of the defects does not exceed 0.009 in^2.

   d. The sum of the greatest dimension of defects in a line does not exceed 3/8 in.

4. Welds showing a response that exceeds the primary reference level or not meeting the requirements specified in Article 3.05, "Identifying Pressure Rail Welds," are not acceptable.

B. Welds indicating a lack of fusion or including cracks when tested by the magnetic particle examination procedure will be considered defective.

C. The hardness of the weld measured on the head of the rail in the center of the weld shall be equal to the Brinell hardness of the parent metal with a tolerance of +/- 20 Brinell hardness points. Welds with hardness not meeting this requirement will be considered defective.

D. Pressure rail welds which cannot be identified by reference to Production Report or due to loss of weld identification painted on the rail shall be considered defective and may be removed from payments due Contractor unless positive identification can be made.

3.08 REPAIR OF DEFECTIVE WELDS

A. Rail welds rejected during inspection or testing shall be cut out and shall be rewelded. When a single rejected weld cannot be replaced by a single weld, defective welds shall be replaced with at least a 15 ft rail welded in its place by 2 thermite welds.

B. Rail shall be cut a minimum of 5-7/8 in. from the defective weld before rewelding.

C. Repairs shall be made at no additional cost to the VTA.

3.09 TESTING AGENCY AGREEMENT

A. Within 10 calendar days after award of the Contract, Contractor shall submit to the Engineer for review and appropriate action, the agreement between Contractor and the Testing Agency. The agreement shall contain the following clauses:

1. All test reports shall be furnished directly to VTA in originals by the Testing Agency.
2. All correspondence related to testing matters from the Testing Agency to Contractor shall be copied to VTA.

B. All test reports shall be delivered to VTA to allow for 5 working days review and appropriate action by VTA before being eligible for payment.

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SECTION 34 11 44

THERMITE RAIL WELDING

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for thermite rail welding. Thermite welding shall be used for special trackwork and precurved rail and can be substituted for pressure welding to connect rail strings, repair defective welds, and at locations directed by VTA or where pressure welding is not feasible, subject to approval of VTA.

1.02 REFERENCED STANDARDS

A. American Railway Engineering and Maintenance-of-Way Association (AREMA): Manual For Railway Engineering, Volume 1, Chapter 4, Part 2, Section 2.2, "Specification for Fabrication of Continuous Welded Rail (CWR)," and Section 2.5, "Thermite Welding - Rail Joints."

B. American Society for Testing and Materials (ASTM):

1. E18 Standard Test Methods for Rockwell Hardness and Metallic Materials.

2. E94 Standard Guide for Radiographic Examination.

3. E164 Standard Practice for Contact Ultrasonic Testing of Weldments.

4. E709 Standard Guide for Magnetic Particle Testing.

1.03 QUALITY ASSURANCE

A. Rail Straightness: Contractor shall check for end straightness before welding.

B. Both ends and tops of rails shall be straight edged using a 36 in. metal straightedge, and deviations from straight shall be measured with a metal taper gauge.

C. Rails which are at or exceed the tolerances in AREMA Manual, Chapter 4, Part 2, Section 2.1, Article 2.1.13 shall be straightened or cropped by Contractor.

1.04 SUBMITTALS

A. Thermite Welds: Before thermite welding, submit a detailed description of proposed method and procedure. Method and procedure specified shall comply with that of the weld kit manufacturer and shall include name of manufacturer and details of following operations:

1. Preparation of rail for welding.

2. Rail end spacing, tolerances, and procedures to maintain rail gap during welding operation.

3. Rail alignment.

4. Placing and bolting prepared molds.

5. Preheating rail, including method, temperature and time.

6. Crucible tapping and procedures including duration of weld and cooling time.

7. Trimming and grinding of weld.

8. Method to be used for removing gates and risers.

B. Submit details and example of methods of identifying thermite welds on rail in the field.

C. Contractor shall demonstrate welding ability and qualification of welding personnel by the performance of thermite weld samples. VTA will be notified at least 2 days before the making of demonstration and sample welds. A representative of VTA and an inspector of the Testing Agency will be present during the time the demonstration and sample welds or when subsequent rewelds are being performed.

D. Qualification of Contractor Welding Personnel: Contractor shall provide names and individual qualification of personnel proposed for track welding and weld grinding indicating number of years of experience, previous track welding jobs performed for this or other railroad contractors, and levels of experience and/or certification. Submittal shall include copy of certification provided by an authorized representative of the thermite weld kit manufacturer proposed by Contractor for use on this Project. Contractors who do not have qualified and certified railroad track welders shall be given opportunity to obtain certification and demonstrate such competence.

E. Thermite Weld and Demonstration Samples: Before production welding and at Contractor's expense, 1 sample thermite weld shall be made and tested by an independent laboratory acceptable to VTA. The certified test results and the sample weld shall be submitted to VTA. The sample weld shall be tested as follows:

1. Radiographic Examination: Sample weld shall be ground smooth to within 0.005 in. of the parent rail section and radiographically tested with a minimum of 5 exposures; 1 through the head, 1 through the flange, 1 through the web, and 1 through each of the 2 flanges. Radiography shall be performed in accordance with ASTM E94. Radiographic film shall be Type 1 and Type 2. Exposed film density shall be within the range of 1.5 to 3.8. The film and certified tests reports shall be forwarded to VTA for approval.

2. Ultrasonic Test and Magnetic Particle Test: Sample thermite weld shall be ultrasonically tested and tested using the magnetic particle method as stated in Article 3.03D, herein. Certified test reports shall be forwarded to VTA.

3. Test weld shall be visually examined for cracks.

4. Weld hardness test, measured on the head of the rail in the center of the weld, shall show that the hardness of the weld shall be equal to the average Brinell hardness of the 2 rails joined with a permissible tolerance of +/- 20 Brinell points.

F. Thermite Weld Production Report: Submit sample copy of form to be used by Contractor to record production of each thermite field weld made. Proposed report form shall include complete identification of weld production and of exact location of each termite weld installed in permanent location in track. Sample copy of a thermite weld production report is attached to this Section identifying the format and content that will be acceptable to VTA.

G. Weld Testing Agency: Submit copy of Contractor agreement with Weld Testing Agency as specified hereinafter.

H. The Testing Agency will submit a list of instruments to be used for the testing of rail welds. This list shall include the manufacturer's name, model number, serial number and calibration certificate for each instrument

1.05 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 – PRODUCTS

2.01 WELD MATERIALS

A. Weld materials shall conform to Contractor's thermite weld submittals approved by VTA. Once approved, Contractor shall not change thermite welding materials supplier, thermite welding process or track welders and grinders without resubmittal and subsequent approval of the new supplier, process or personnel by VTA.

PART 3 – EXECUTION

3.01 PREPARATORY WORK FOR WELDS

A. Condition of rails to be welded shall conform to the AREMA Specifications as follows:

1. Deviations of the lateral or horizontal line in either direction at the rail ends shall not exceed a mid-ordinate of 1/32 in. in 36 in. using a straight edge, and an ordinate of 1/32 in. at the end quarter-point.

2. Uniform upsweep at rail ends shall not exceed an ordinate of 1/32 inches in 36 inches, and 1/32 inches. maximum ordinate shall not occur at a point closer than 18 in. from the rail end.

3. Surface downsweep and droop will not be acceptable.

4. Rail that cannot be straightened permanently shall be cut back a sufficient distance to achieve required alignment. Rails shall only be sawed or abrasive wheel cut to length. Variation in end squareness shall not exceed 1/32 in. Burrs shall be removed. The method of end finishing rails shall be such that the rail end shall not be metallurgically or mechanically damaged. Rail shall only be cut back when VTA is satisfied that the rail cannot be satisfactorily straightened.

B. All rails for welding by Contractor shall be oriented in the same direction such that rail brands face the field side or outside of the track and rail stamping is oriented to the gauge side of the track being constructed. Turning of rails to accomplish proper orientation shall be included in the work items to which they apply.

C. Final location of thermite welds in track shall allow not less than 2 in. from edge of any track plate to the edge of the thermite weld. Contractor shall adjust plate spacing as necessary to avoid thermite welds occurring closer than 2 in. and shall not exceed maximum plate spacing required by the shop drawings applicable to the track segment being constructed. Respacing of plates to accomplish proper clearance to thermite welds shall be included in the items of work to which they apply.

3.02 RAIL WELDING QUALITY ASSURANCE

A. Mismatched, nicked, damaged or jagged rail ends shall be either sawed or cut with an abrasive rail cutter.

B. Defective welds shall be cut by saw or by an abrasive rail cutter. Torch cutting on rail ends to be welded is not acceptable.

C. Alignment of rails to be welded shall be at the head of the rail. Alternative alignment methods shall be used only upon approval by VTA.

1. Vertical alignment shall provide for a flat running surface. Differences of height of the rail shall be corrected in the base.

2. Horizontal alignment shall be accomplished in such a manner that any difference in the width of heads of rails shall be divided equally on both sides of the head. Where the difference, when divided by 2, exceeds 3/64 in., the gauge side shall be aligned flush allowing differences in the width of heads to occur on the field side.

3. Horizontal offsets shall not exceed 3/64 in. at the head nor 1/8 in. at the base.

D. Surface Misalignment Tolerance:

1. Combined vertical offset and crown camber shall not exceed 1:300 to a maximum of 1/16 in. at ambient temperature in accordance with AREMA Specification.

2. Welds displaying dip camber in accordance with AREMA Specification will not be acceptable.

E. Gauge Misalignment Tolerance: Combined horizontal offset and horizontal kink camber shall not exceed 1:300 to a maximum of 1/16 in. at ambient temperature in accordance with AREMA Specification.

F. A finishing deviation of the parent section of rail head surface shall not exceed + 1/64 in. to - 0.00.

G. Sides of rail head weld shall be finished to +/- 1/64 in. of parent section. Top and bottom of rail base shall be finished to within 1 in. of lowest rail.

H. Web zone, including underside of head, web, and both fillets on each side, shall be finished to within 1/8 in. of parent contour but shall not be deeper than the parent section. Finishing shall eliminate cracks.

I. Notches created by offset conditions, twisted or misshaped rails shall be eliminated by grinding to blend variations.

J. Fins on weld due to grinding shall be removed before testing.

K. Whenever possible, grinding shall be accomplished immediately following welding at an elevated temperature. When grinding is done at ambient temperature, avoid grinding burns and metallurgical damage.

L. Finish grinding on running surface and gauge face of rail head shall be accomplished within 24 in. of either side of the center of the thermite weld.

M. Failure of Contractor to conform to these requirements will result in a work stoppage issued by VTA until these requirements are in compliance.

3.03 INSPECTION AND TESTING OF WELDS

A. Magnetic particle and ultrasonic inspection and testing of thermite welds shall be performed by the Testing Agency within 5 work days of production by the construction Contractor.

B. Inspect welds in accordance with the AREMA Specifications and furnish test results to VTA.

C. Defective welds shall be repaired as specified in Article 3.07, "Repair of Defective Welds," herein.

D. Each thermite rail weld shall be tested ultrasonically and by dry powder magnetic particle method in the field for defects within 5 days after the weld has been made. Testing shall be performed by a qualified inspector of the Weld Testing Agency acceptable to VTA.

1. Ultrasonic test equipment shall be capable of detecting a 3/64 in. discontinuity 6 1/2 in. below top of rail. Ultrasonic inspection of welds shall be performed in accordance with ASTM E164. Weld Testing Agency shall develop an ultrasonic testing procedure which shall indicate incompletely fused welds. The testing procedure shall be submitted to VTA. Welds shall be inspected in accordance with accepted procedure and shall be visually inspected for surface cracks. Testing shall not be performed until weld has cooled to ambient temperature. Inspection agency shall furnish an ultrasonic test report form that shall record 20 inspected welds per 8 1/2 in. x 11in. sheet. The form shall include the location of the weld in track, the results of the ultrasonic inspection including the size of defects found in the head, web or base of rail; the results of visual inspection; recommendation for correcting welds found defective, name of inspector and other information needed. The form shall be subject to acceptance by VTA. Welds found defective shall be repaired as specified in Article 3.07, "Repair of Defective Welds," herein.

2. Inspection of thermite welds by the dry powder magnetic particle method shall be in accordance with ASTM E709.

3. VTA may require Contractor to perform Brinell hardness test in accordance with ASTM guidelines as needed if the condition of welds relative to hardness is uncertain. Brinell hardness of rail welds shall be measured and compared to the parent metal.

E. Welds not meeting the requirements specified in Article 3.05, "Location and Acceptance Criteria for Thermite Welding," herein, will not be acceptable and shall be rejected and cut out and replaced with acceptable weld or welds as specified in Article 3.07, "Repair of Defective Welds," herein.

3.04 IDENTIFYING RAIL WELDS

A. Upon completion of each thermite weld, at the time the weld is made, Thermite Weld Production Report shall be prepared in the field by Contractor's welder and shall be delivered to VTA documenting production of each weld. Included shall be the sequence number assigned to each weld, the heat numbers of rail on each side of welds, the location of each weld placed in track indicated in engineering stationing. Contractor's Thermite Weld Production Report shall also include all of the additional information shown on the attached sample report form.

B. Each rail weld shall be identified in the field at the time the weld is made in 2 in. high letters and numbers providing the sequential weld number, weld date, rail temperature at the time of the weld and the welder's initials. This information shall be painted on the gauge side of the rail web with permanent paint.

C. Failure by Contractor to conform to these requirements will result in a work stoppage issued by VTA until these requirements are in compliance.

3.05 LOCATION AND ACCEPTANCE CRITERIA FOR THERMITE WELDING

A. Running rail and special trackwork in ballasted track shall be joined in the field by thermite rail welding as specified in Article 1.01B, herein.

B. Field thermite welds shall not be located within the following locations:

1. Within 10 feet of a field weld in the same rail.

2. Within 13 feet from the center of any bolted or glued joint.

C. Preparation of Rail Ends: Rail ends shall be saw-cut at a right angle to the rail meeting end squareness indicated in Article 3.01A.4, herein. Surfaces of rail for a length of approximately 6 in. from the end of the rails shall be cleaned by grinding just before welding to remove all grease, dirt, loose oxide, oxidized metal, scale, and moisture. Burrs and lipped metal which would interfere with the fit of mold shall be removed.

D. Weld Gap: At the time of field thermite welding the rails shall have the rail gap recommended by the manufacturer of the weld kit and shall be aligned to produce a weld which, with respect to alignment, shall comply with AREMA recommended practices and these technical specifications. Should the rail gap be larger than the manufacturer's recommended gap after the rails have been adjusted for zero thermal stress, then sufficient rail shall be removed from 1 or both rails to permit insertion of a rail not less than 13 ft long which shall provide the recommended gaps at each end for field welding. At a location where the rail gap is smaller than the manufacturer's recommended gap, the recommended gap shall be obtained by sawing a piece from 1 rail.

E. Weld Finish: Finishing tolerances applicable to 115RE rail thermite welds shall be as identified in Articles 3.02F through M, herein.

F. Thermite welds shall be tested ultrasonically and by the dry powder magnetic particle method. Brinell hardness of thermite welds may also be tested. Test results shall be delivered to VTA as specified in Article 3.08, "Testing Agency Agreement," herein. Tests shall be performed according to the procedure for testing as approved and identified herein by VTA. Thermite welds shall be determined acceptable or defective according to the criteria specified in Articles 3.02F through M, Article 3.05E, and in Article 3.06, "Defective Welds," herein.

3.06 DEFECTIVE WELDS

A. Defective welds when tested in accordance with the ultrasonic and radiographic test procedures in these technical specifications shall be determined as follows:

1. Welds showing a response at any level that is identified as a crack or lack of fusion will not be acceptable.

2. Welds showing a response that is less than 50 percent of the primary reference level will be acceptable.

3. Welds showing a response greater than 50 percent but that do not exceed primary reference level are acceptable, provided that all of the following apply:

   a. The defects are evaluated as slag or porosity.

   b. The largest defect does not exceed 3/16 in. in its largest dimension.

   c. The total area of the defects does not exceed 1/4 in.^{2}.

   d. The sum of the greatest dimension of defects in a line does not exceed 3/8 in.

4. Welds showing a response that exceeds the primary reference level or not meeting the requirements of Article 3.04, "Identifying Rail Welds," herein, shall not be acceptable.

B. Welds indicating a lack of fusion or including cracks when tested by the magnetic particle examination procedure will be considered defective.

C. The hardness of the weld measured on the head of the rail in the center of the weld shall be equal to the Brinell hardness of the parent metal with a tolerance of +/- 20 Brinell hardness points. Welds with hardness not meeting this requirement will be considered defective.

D. Defective thermite welds shall be repaired as specified in Article 3.07, "Repair of Defective Welds," herein.

3.07 REPAIR OF DEFECTIVE WELDS

A. Rail welds rejected during inspection or testing shall be cut out and shall be rewelded. When a single rejected weld cannot be replaced by a single weld, defective welds shall be replaced with at least a 15 feet rail welded in its place by 2 thermite welds.

B. Cutting of rail to remove failed or rejected thermite welds shall be at least 6 in. from the centerline of the thermite weld to be cut out. Cutting of rail to remove other rejects or mechanical damage shall be located as specifically directed by VTA for each location or condition.

3.08 TESTING AGENCY AGREEMENT

A. Within 10 calendar days after award of the Contract, Contractor shall submit to VTA for review and appropriate action the agreement between Contractor and the Testing Agency. The agreement shall contain the following clauses:

1. All test reports shall be originals and furnished directly to VTA by the Testing Agency.

2. All correspondences related to testing matters from the Testing Agency to Contractor shall be copied to VTA.

B. All test reports shall be delivered to VTA to allow for 5 working days review and appropriate action by VTA before being eligible for payment

END OF SECTION 34 11 44

SECTION 34 11 83

BALLAST

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for furnishing, spreading and distributing ballast on ballasted primary track and ballasted special trackwork and related incidental work.

1.02 REFERENCED STANDARDS

A. American Railway Engineering and Maintenance-of-Way Association (AREMA):

1. Manual for Railway Engineering.

B. American Society for Testing and Materials (ASTM):

1. C88 Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
2. C117 Standard Test Method for Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing.
3. C127 Standard Test Method for Specific Gravity and Absorption of Coarse Aggregate.
4. C136 Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
5. C142 Standard Test Method for Clay Lumps and Friable Particles in Aggregates.
6. C535 Standard Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
7. D75 Standard Practice for Sampling Aggregates.
8. D4791 Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate.

C. State of California, Department of Transportation (Caltrans), Standard Test Methods:

1. Test 201 Soil and Aggregate Sample Preparation.
2. Test 202 Sieve Analysis of Fine and Coarse Aggregates. Equivalent to ASTM C117 and ASTM C136, except that results shall be measured to the nearest 0.1 percent.
3. Test 211 Abrasion of Coarse Aggregate by Use of the Los Angeles Rattler Machine. Equivalent to ASTM C535.
4. Test 214 Soundness of Aggregates by Use of Sodium Sulfate. Equivalent to ASTM C88.

1.03 SUBMITTALS

A. Submit

1. Quarry qualification test report of specified quarry qualification testing.

2. Plan for Handling and Placing Ballast. Include source, type of equipment to be used, location of stockpiles and method of distribution.

1.04 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 – PRODUCTS

2.01 BALLAST

A. General: Ballast shall be crushed rock with fractured faces composed of hard, strong and durable particles. Approved crushed material shall be angular, rough surface, clean and free of sand, loam, flat, elongated, soft or disintegrated pieces, vegetation or other deleterious substances and conforming to the AREMA Manual and as specified herein.

B. Source

1. Contractor shall select the ballast source from a quarry that has a 5 year history of supplying high quality ballast.

2. Source shall be subject to VTA approval pursuant to quality requirements specified hereinafter.

C. Quality Requirements

1. Carbonate rocks, crushed slag ballast or crushed river gravel are not acceptable.

2. Sample in accordance with ASTM D75 and prepare samples in accordance with California Test 201.

3. Deleterious material in the ballast shall not exceed the following amounts, as determined by the testing method specified herein:

   a. Maximum amount of material passing the No. 200 standard sieve, tested in accordance with California Test 202 (ASTM C117 and ASTM C136), shall be 0.5 percent. Test results shall be rounded to the nearest 0.1 percent.

   b. Maximum clay lumps and friable particles, tested in accordance with ASTM C142, 0.5 percent.

   c. Rounding of test results to whole numbers will not be allowed.

d. Ballast found to have any root material, tree limbs, or any other deleterious vegetable matter will be rejected. If ballast containing vegetable matter is found to be installed in the trackway, all ballast in that section shall be removed from the right of way to the satisfaction of VTA and disposed of off site without cost to VTA.

4. Wear of the material shall not exceed 32 percent when tested in accordance with California Test 211 (ASTM C535).

5. Loss shall not exceed 5.0 percent after 5 cycles when tested in accordance with California Test 214 (ASTM C88) for sodium sulfate soundness.

6. Absorption shall not exceed 1.0 percent when tested in accordance with ASTM C127.

7. Thin or elongated particles (length longer than 3 times average thickness) shall not exceed 5 percent when tested in accordance with ASTM D4791.

8. Gradation Requirements

a. Gradation shall be tested in accordance with California Test 202 (ASTM C117 and ASTM C136).

b. Ballast in ballasted track shall conform to AREMA Manual, Chapter 1, Part 2, Table 2-2, Size 4 (the following gradation requirements are listed for convenience):

Sieve Size	Percent by Weight Passing Sieve
2 inch	100
1-1/2 inch	90 - 100
1 inch	25 - 60
3/4 inch	0 - 10
3/8 inch	0 – 5

9. The maximum moisture content of the ballast shall not exceed one percent at the time of measurement.

D. Preparation of Ballast: Ballast shall be washed clean of deleterious materials including fine particle contamination to the satisfaction of VTA at the quarry before loading and delivery to the site.

2.02 INSPECTION AND TESTING

A. General

1. Ballast shall be subject to inspection by VTA at any time at the source, in transit or on site.

2. When VTA determines that ballast does not meet specified requirements, VTA will notify Contractor promptly, and Contractor shall discontinue ballast operations and take appropriate corrective measures. Contractor shall stop further ballast operations until the fault has been corrected and defective material has been removed, disposed of and replaced at no additional cost to VTA.

B. Quality Control Testing

1. Testing shall be performed by Vendor's independent certified testing laboratory approved by VTA.

2. The Vendor shall provide laboratory certification that ballast Material meets the Specifications of this Section.

3. If the Vendor observes ballast material not suitable for work, or not in compliance with this part, VTA must be notified within three (3) hours of discovery of condition.

4. The product delivered shall be from the same source from which samples were tested and found to conform to the Specification and shall be of the same type and quality that which was tested.

PART 3 – EXECUTION

3.01 INSPECTION

A. Verify that surface on which ballast will be placed is clean and clear of debris and obstructions and meet specified requirement. Correct defects when defects on surface are found.

3.02 HANDLING

A. Keep ballast clean and free from segregation during transporting, handling, placing operations, and subsequent work.

B. Ballast once distributed including ballast placed as first lift or bottom ballast shall not be used for driving surface or for any other access except distribution of ties. Contractor shall prevent by whatever means necessary driving on ballast and use of track ballast for access once ballast is distributed. Ballast sections used for drive ways, rutted by equipment, or used for ramps and track crossings shall be re-graded and consolidated or completely removed and replaced by Contractor at the direction of VTA.

3.03 INSTALLATION

A. Place, spread, consolidate, tamp, and dress ballast as specified in Section 34 11 26, Ballasted Track Primary Construction.

3.04 FAILED AND REJECTED BALLAST

A. When Contractor has been notified that ballast does not meet these technical specifications, Contractor shall discontinue ballast operations. Ballast in transit, only, may be dumped in stockpile or on separate track area, but no additional ballast shall be hauled.

B. No track material of any kind shall be distributed on any part of rejected area.

C. Ballast areas rejected, based on daily or special area sampling and test results, shall represent the entire area defined by the sample and test results, and all material within that area will be subject to removal and replacement. Observations or visual interpretations of conformance of ballast to these technical specifications will not be the basis of acceptance of the ballast by VTA.

D. Alternative methods of treating failed and rejected ballast in place on the right-of-way such as washing or flushing, vacuuming, or other in-place methods will not be acceptable substitutes to removal and replacement of failed or rejected ballast.

E. VTA may not waive or alter these requirements without providing written direction to Contractor on a case-by-case basis. Any such approval given shall not be interpreted as blanket approval, waiver or modification of these technical specifications.

F. Failure of Contractor to comply with the requirements of this Section will subject Contractor to a work stoppage issued by VTA until deficiencies are corrected. Track segments containing failed or rejected ballast according to these requirements shall result in removal of track section affected from progress payments until deficiencies are corrected.

END OF SECTION 34 11 83

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SECTION 34 11 84

SUBBALLAST

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for furnishing, spreading, and compacting subballast and associated filter fabric under the LRT tracks.

1.02 REFERENCED STANDARDS

A. State of California, Department of Transportation (Caltrans), Standard Specifications.

1. Section 17 Watering
2. Section 26 Aggregate Bases

B. State of California, Department of Transportation (Caltrans), Standard Test Methods.

1. Calif. Test 201 Method of Soil and Aggregate Sample Preparation
2. Calif. Test 202 Method of Tests for Sieve Analysis of Fine and Coarse Aggregates
3. Calif. Test 205 Method of 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 Resistance "R" Value of Treated and Untreated Bases, Subbases and Basement Soils by the Stabilometer

C. American Society for Testing and Materials (ASTM):

1. D6938 Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

1.03 SUBMITTALS

A. The following submittals shall be made by the Contractor.

1. Test reports and samples of materials to be used along with compaction testing reports as described in Section 31 00 00, Earthwork shall be submitted to VTA Representative for review.

1.04 MEASUREMENT AND PAYMENT

A. Measurement: Subballast shall be measured by the cubic yard.

B. Payment: The contract price paid per cubic yard for Subballast shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Subballast complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

C. Full compensation for furnishing and installing geotextile fabric under subballast and furnishing and installing filter fabric under ballast at the locations shown on the Plans, shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 – PRODUCTS

2.01 SUBBALLAST MATERIAL

A. Aggregate for subballast at the time it is deposited on the prepared subgrade or subbase shall conform to the following requirements.

1. Subballast shall comply with Caltrans Standard Specifications, Section 26, Class 2 Aggregate Base, 3/4-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	Sizes Maximum
2”	0
1-1/2“	100
¾”	90-100
No. 4	35-55
No. 30	10-30
No. 200	2-9

2. 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	90-100	35 min.

3. At the time subballast is placed, it shall be free from organic matter and other deleterious substances.

2.02 SOURCE QUALITY CONTROL

A. The Contractor shall perform sampling and tests of the subballast material to determine compliance with specified requirements. Samples will be taken from material as delivered to the site.

PART 3 – EXECUTION

3.01

A. Excavation or embankment for track subgrade or sub base preparation shall be in accordance with Section 31 00 00, Earthwork.

3.02 EXAMINATION

A. The subgrade or subbase to receive subballast course, immediately prior to spreading, shall conform to the compaction and elevation tolerances specified and indicated for the material involved and shall be free of standing water and loose or extraneous material.

3.03 INSTALLATION STANDARDS

A. Apply subballast course over the prepared subgrade or subbase and compact.

B. Subballast course shall be minimum uniform thickness after compaction of dimensions indicated. Unless indicated otherwise on plans, compacted thickness shall be 8 inches.

3.04 SPREADING OF MATERIAL

A. Deliver aggregate for subballast as uniform mixture and spread in layers without segregation.

B. Ensure subballast material is free of pockets of large and fine material. Remix segregated materials until uniform.

C. Moisture-condition subballast material to near optimum moisture content.

D. Subballast 6 inches and less in thickness may be spread and compacted in one layer. For thicknesses greater than 8 inches, spread the subballast and compact in two or more layers of uniform thickness not greater than 6 inches each.

3.05 COMPACTION

A. Each layer of compacted subballast material shall be not less than 95 percent of the standard density determined by California Test Method No 216.

B. Thickness of finished subballast course shall not vary more than 1 inch from the indicated thickness at any point. Reshape or rework, water, and recompact subballast to achieve compliance with specified requirements that does not conform to this requirement.

C. The surface of the finished subballast course at any point shall not vary more than 1 inch above or below the indicated grade.

3.06 FIELD QUALITY CONTROL

A. The Contractor shall perform tests in accordance with ASTM D2922 to determine compliance with specified requirements for density and compaction of subballast, and with ASTM D3017 to determine moisture content of the installed subballast.

END OF SECTION 34 11 84

SECTION 34 11 85

TIRE SHRED VIBRATION DAMPING LAYER

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for furnishing and placing tire shred vibration damping layer in conformity with the lines, grades, thickness and typical cross sections, as shown on the drawings.

1.02 REFERENCED STANDARDS

A. American Society for Testing and Materials (ASTM):

1. D3786 Standard Test Method for Hydraulic Bursting Strength of Knitted Goods and Nonwoven Fabrics - Diaphragm Bursting Strength Tester Method (Discontinued 1996).
2. D4491 Standard Test Method for Water Permeability of Geotextiles by Permittivity.
3. D4533 Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
4. D4632 Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
5. D4751 Standard Test Method for Determining Apparent Opening Size of a Geotextile.
6. D4833 Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.

1.03 MEASUREMENT AND PAYMENT

A. Measurement: Tire Shred Vibration Damping Layer shall be measured by the cubic yard.

B. Payment: The contract price paid per cubic yard for Tire Shred Vibration Damping Layer shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Tire Shred Vibration Damping Layer complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 MATERIALS

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 any contaminants such as oil and grease, which could leach into the groundwater or create a fire hazard. Tire shreds shall not contain remains of tires that have been subjected to a fire. Tire shreds shall have not more than 1 percent, by weight, of metal fragments which are not embedded fully or partially in rubber. Metal fragments that are partially embedded in rubber shall protrude not more than 1 in. from the cut edge of the tire shred on 75 percent of the pieces, by weight, and not more than 2 in. 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 7 7/8 in. Type A tire shreds shall have 100 percent, by weight, passing the 4 in. square mesh sieve, a minimum of 50 percent passing the 2 in. square mesh sieve, and a maximum of 5 percent passing the No. 4 sieve.

C. Geotextile Fabric: The geotextile fabric shall have property values expressed in "minimum" or "minimum average roll" values that meet or exceed the values stated below, as determined by the most recent test methods specified below. All mechanical property values expressed as "average" or "typical" shall be reduced by 20 percent and then compared to the values specified below.

Geotextile Mechanical Property Value	Test Method	Minimum Permissible
Mullen Burst Strength	ASTM D3786	290 psi (2 MPa)
Trapezoidal Tear Strength	ASTM D4533	50 lbf (222 N)
Grab Tensile Strength (both directions)	ASTM D4632	179 lbf (800 N)
Grab Elongation	ASTM D4632	15 percent
Puncture Resistance	ASTM D4833	50 lbf (222 N)

Geotextile Hydraulic Property Value	Test Method	Permissible
Permeability	ASTM D4491	0.0004 in/s
Apparent Opening Size (AOS)	ASTM D4751	U.S. Std. Sieves No. 16 (1.18 mm) through No. 100 (150 µm)

PART 3 – EXECUTION

3.01 INSTALLATION

A. Subgrade Preparation: The subgrade that will underlie the tire shred course shall meet the grade tolerance, compaction, and other requirements specified in Section 31 00 00, "Earthwork."

B. Geotextiles: The tire-shred course shall be enclosed in a layer of geotextile as shown on the Plans. The geotextile shall be unrolled as smoothly as possible on the surface to minimize wrinkles and folds. Adjacent lengths of geotextile shall be overlapped a minimum of 18 in. 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 6 in. 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 track-mounted bulldozers, rubber-tired motor graders, backhoes, or other 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 6 passes of a vibratory smooth drum roller with a minimum static weight of 20,000 lbf. If the top of any layer becomes contaminated by addition of foreign material, the surface of each layer shall be maintained during compaction operations in such a manner that a uniform texture is produced and the tire shreds are firmly keyed. The completed surface of the tire-shred course shall be brought to a condition of uniform stability and compaction. To compensate for settlement of the tire shreds caused by the weight of the overlying material, the top surface of the tire shred fill shall be overbuilt to an elevation 1 inch, plus 9/16 inches, minus 0 inches, above the finished elevation shown on the Plans.

END OF SECTION 34 11 85

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SECTION 34 11 93

MISCELLANEOUS TRACKWORK ELEMENTS

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for furnishing and installing miscellaneous trackwork elements.

B. Miscellaneous trackwork elements include, but are not limited to, the following items:

1. Superelevation tags;
2. Epoxy;
3. Filter fabric;
4. Abrasion pads, adhesive and rubber filler;
5. Insulated Rail Joints;
6. Concrete Crossing Panels;
7. Emergency guard rail and fastenings;
8. Bumping posts;
9. Restraining Rail.

1.02 REFERENCED STANDARDS

A. Association of American Railroads (AAR).

B. American Railway Engineering and Maintenance-of-Way Association (AREMA):

1. Manual of Railway Engineering (AREMA Manual).

C. American Railway Engineering and Maintenance-of-Way Association (AREMA):

1. A490 Standard Specification for Structural Bolts, Alloy Steel Heat Treated, 150 ksi Minimum Tensile Strength.
2. C882 Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear.
3. C883 Standard Test Method for Effective Shrinkage of Epoxy-Resin Systems Used with Concrete.

4. D257 Standard Test Methods for DC Resistance or Conductance of Insulating Materials.

5. D570 Standard Test Method for Water Absorption of Plastics.

6. D638M Standard Test Method for Tensile Properties of Plastics (Metric).

7. D695M Standard Test Method for Compressive Properties of Rigid Plastics (Metric).

8. D732 Standard Test Method for Shear Strength of Plastics by Punch Tool.

9. D790M Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials (Metric).

D. State of California, Department of Transportation (Caltrans), Standard Specifications:

1. Section 52 Reinforcement.

2. Section 88 Engineering Fabrics.

1.03 SUBMITTALS

A. Submit:

1. Shop drawings, material specifications, and installation procedures for all miscellaneous track materials including restraining rails, abrasion pads, adhesive, concrete crossing panels, rubber filler, and precast crossing panel end restraint sets.

2. Shop drawings, material specifications, and installation procedures for glued insulated joints.

3. Detailed material specifications including electrical resistivity properties and installation procedures for insulating materials including, insulating tie pads and, insulating bushings

4. Submit catalog cuts and detailed descriptions for the following track inspection tools: Rail thermometer, 36 inch straightedge, taper gauge, combination track level and gauge, torque wrench, multiplier and square nut sockets. Sales brochures that do not provide technical details are not acceptable.

5. Provide additional submittals as required herein.

B. Submit notarized Certificates of Compliance for all track material.

C. Submit concrete crossing panel mix design not less than 60 calendar days before the manufacture of concrete crossing panels.

D. Submit concrete crossing panel compressive strength certification and test report not less than 60 calendar days before the manufacture of concrete crossing panels.

E. Submit manufacturer's VTA-approved Quality Assurance Program plan not less than 60 calendar days before the manufacture of concrete crossing panels.

F. Submit individual panel designs and layouts for each grade crossing to be furnished and installed not less than 60 days before manufacture.

G. Submit installation procedures for emergency guard rail.

H. Submit installation procedures for bumping posts.

1.04 QUALITY ASSURANCE

A. Manufacturer's Qualifications for Concrete Crossing Panels:

1. Manufacturer shall have a minimum of five years of experience in the manufacture and supply of concrete crossing panels to the railroad and transit industries.

2. Manufacturer shall be regularly engaged in the production of concrete crossing panels.

3. Before manufacturing, Contractor and VTA shall jointly conduct a QA Facility Survey of the manufacturing facility for process capability.

4. Manufacturer shall comply with all applicable local and Caltrans requirements.

B. The manufacturer shall warrant all concrete crossing panels for a period of not less than 5 years against all manufacturing defects.

1.05 MEASUREMENT AND PAYMENT

A. The furnishing of the following items will not be measured and paid separately, and all costs therefore shall be considered incidentals and included in the prices paid for the items of work to which they pertain:

1. Superelevation tags;

2. Epoxy;

3. Filter fabric;

4. Abrasion pads, adhesive, and rubber filler.

B. Insulated rail joints will be measured and paid by each pair. The unit price paid for the insulated rail joints shall include all material and equipment required for complete furnishing and installation.

C. Payment for Concrete crossing panels shall be included in the payment for track construction for at-grade and pedestrian crossings as indicated in Section 34 11 29, Grade and Pedestrian Crossing Track Construction.

D. Emergency guard rail and fastenings will be measured and paid at the contract price per linear foot of the single emergency guard rail furnished and installed. Payment will include furnishing of plates, rail clips, cutting, curving and beveling of rail ends as required for a complete installation.

E. Bumping Posts will be measured and paid for at the contract unit price for each salvaged or new bumping post installed as shown on the drawings.

PART 2 – PRODUCTS

2.01 SUPERELEVATION TAGS

A. Metal tags used to mark superelevation of track shall be a corrosive resistant metal such as anodized aluminum or brass.

B. Tags shall be stamped in 1/4 in. increments from zero to maximum superelevation.

C. Tags shall be a minimum of .05 inches thick with dimensions indicated on VTA Standard Drawing STW-016.

D. Superelevation tags shall be secured to concrete cross ties with epoxy.

1. Epoxy shall meet the requirements of the epoxy specified in Article 2.05, "Epoxy," herein.

2.02 INSULATED RAIL JOINTS

A. Insulated rail joint shall be pre-fabricated insulated joints unless otherwise noted or approved by the Engineer. Bonded insulated rail joints shall be preassembled in rails with 36 in. long, 6-hole joint bars equipped with pin bolted. Length of plug rail shall be 19 ft 6 inches.

2.03 CONCRETE CROSSING PANELS (LRT)

A. Concrete crossing panels (LRT) shall be pre-fabricated highway grade crossing panels with lengths of either 12 ft or 9 ft measured parallel to the centerline of the track. Material shall be precast reinforced concrete.

B. Panels shall be designed to facilitate installation on concrete ties with spring clips supporting 115RE tee rail and flangeway as indicated on the Plans. Pre-cast concrete panels shall be modified such that no concrete or metal portion of the panel comes into contact with the rail or rail fastening assembly. Panels shall be constructed in a manner that shall ensure their non-conductivity. Panels shall be tested for non-conductivity before shipment. Panel dimensions shall be as indicated on the Plans.

C. Concrete crossing panels (LRT) shall be furnished with a solid pre-cast rubber filler, designed for an integral installation with panels as indicated on the Plans. The concrete panel/rubber filler system shall be designed for use with VTA-furnished Type B and C concrete cross ties which are 9 ft in length. Neither the concrete panels nor the rubber filler shall require screws or bolts to secure panels or rubber filler to the concrete crosstie. Multiple panels of the standard length shall be furnished and installed to the minimum crossing lengths indicated on the Plans.

D. Concrete panels shall meet the following requirements:

1. Panel shall be encased at the top in a welded steel angle frame that is tack welded to a top layer of reinforcing steel. Steel frame shall be bonded to concrete with 1/2 in. diameter, 4 in long steel studs welded to the frame with a spacing not to exceed 12 in.

2. Crossing panels shall be of one-piece modular section without shims to support the panels.

3. Crossing panel materials shall be of insulator type design to retard stray current. Crossing panel material shall provide volume bulk resistivity of 40 x 10^{10} $\Omega\cdot$in according to

ASTM D257.

4. Design crossing panels to seat on the entire tie surface, providing full bearing except in the fastening area.

5. Design crossing panel assembly to fit securely under the railhead on the gauge side and field side of the rail.

6. Concrete panels shall be post-tensioned.

7. Reinforcing steel shall be Grade 420, #16 bars with a spacing of 12 in. or less in both directions. Two layers of reinforcing steel shall be placed within the concrete panel with a minimum concrete cover of 1-1/2 in. and a minimum distance between layers of 2 in.

8. Concrete compressive strength at 28 days shall be minimum 5800 psi.

9. Concrete crossing panels shall be free of voids and aggregate separation.

10. Concrete crossing panels mix design shall use only fractured aggregate.

11. Water/cement ratio (ratio by weight of water to all cementitious materials) shall be 0.40 maximum. Cementitious materials shall comprise cement, fly-ash, and micro-silica.

12. Concrete top surface shall be finished with a heavy brush finish. Exposed steel frame surface shall be free of concrete. The top and bottom surface flatness tolerance shall be +/- 1/16 in.

13. Field panels shall be provided with two lifting attachments. Gauge panels shall be provided with 4 lifting attachments. Lifting attachments shall not protrude above top of panel surface. Lifting attachments shall be designed to allow lifting of the panel with any 2 attachments without damage to the panel.

14. Concrete field side panels shall include a continuous side surface from the top of the panel to the top of the ties to interface with and retain highway paving material.

15. Furnish crossing which, after removal and when being reinstalled, does not require new material.

16. Design crossing panels for the following track gauges, measured between the inside faces of the running rail at a point 5/8 in. below the plane defined by the top of the 2 rails:

    a. 56-1/2 in. for Type C ties.

17. Flangeway width: Minimum 2-1/2 in., maximum 2-3/4 in.

18. Flangeway depth: Minimum 1-3/4 in., maximum 2 in.

E. Rubber filler shall meet the following requirements:

1. On field side of rails, filler shall form a continuous surface from panel to rail with no gaps exceeding 1/4 in. between rail and concrete panels. Gap between contiguous concrete panel steel frames shall not exceed 1/4 in. Surface grade mismatch from one panel to the next shall not exceed 1/4 in.

2. Filler shall be resistant to abrasion, ozone, and petroleum products.

3. Filler surface shall include a skid resistant pattern (tire tread, diamond shape or similar). Depth of grooves in pattern shall be no less than 1/8 in. (3 mm).

4. Flangeway shall be not less than 2-1/2 in. and not greater than 2-3/4 in. wide, with maximum depth of 2 in.

5. There should be no gap between field side rubber filler and head of rail, and filler shall be flush with head of rail.

F. Abrasion Pad:

1. A 1/4 in. x 8 in. abrasion pad shall be placed on top of the concrete crossties under crossing panels.

2. Abrasion pad shall be attached to crosstie with adhesive.

3. Abrasion pad shall be in accordance with concrete crossing panel manufacturer's recommendations and as approved by VTA.

4. Epoxy-resin system adhesive material shall be as specified in Section 34 11 29, "Grading and Pedestrian Crossing Track Construction," and as approved by VTA.

G. Crossing Panel End Restraints:

1. Contractor shall request, from VTA, VTA-approved shop drawing detail for end restraints and tie saddles before their manufacture. End restraints shall be required to prevent any longitudinal movement of concrete crossing panels.

2. Contractor shall furnish and install 1 set (8 tie restraints and 8 saddles) for each track in each road crossing. End restraints shall be field welded between the tie saddle and the concrete crossing panel frame.

2.04 EMERGENCY GUARD RAIL (INCLUDING PLATES)

A. Emergency guard rail shall be 115RE, new or secondhand rail with 5 1/2 in. base, meeting the requirements for Class IV rails specified in AREMA Recommended Rail Grading Classification. Rail material for emergency guard rail shall include required relay quality 4- or 6-hole angle bars for the rail sections provided, and shall include necessary relay quality track bolts, nuts, and lock washers for the emergency guard rail provided.

B. Emergency guard rail shall meet the straightness criteria for Class IV rail specified in these technical specifications for steel rails.

C. See Drawing STW-004 for additional dimensions and details for Contractor-furnished end taper plates, spacer shims, rail clips, attachment bolts, and flat washers.

D. Holes in end taper plates, shims and rail clips shall be cleaned and deburred top and bottom.

E. Rail clips and plates shall be low carbon steel as specified in AREMA for steel tie plates.

2.05 EPOXY

A. Epoxy-Resin System: Shall be of 2-component, solvent-free, moisture insensitive, epoxy resin system, 1:1 or 1:2 (B:A) ratio by volume. The material shall not contain asbestos.

1. Component A shall be a modified epoxy resin of the epichlorohydrin bisphenol A Type, containing suitable viscosity control agents and not containing butyl glycidyl ether.

2. Component B shall be an ethylene-amine and an amine adduct combination containing suitable viscosity control agents and accelerators.

3. Properties:

a. Viscosity: 1.2 (lb/(ft·s)) to 1.7 (lb/(ft·s))

b. Pot life, 30 to 38 minutes, minimum.

c. Compressive strength, tested at 28 days in accordance with ASTM D695M: 12,050 psi, minimum.

d. Modulus of elasticity in compression: 475 psi, minimum.

e. Tensile properties: Tested at 14 days in accordance with ASTM D638M.

f. Tensile strength: 5,500 psi, minimum.

g. Modulus of elasticity in tension: 320 psi, minimum.

h. Elongation at break: 1 percent to 2 percent.

i. Flexural properties: Tested at 14 days in accordance with ASTM D790M.

j. Flexural strength: 9,000 psi, minimum.

k. Tangent modulus of elasticity: 630 psi, minimum.

l. Shear strength, tested at 14 days in accordance with ASTM D732: 5,000 psi, minimum.

m. Water absorption, tested at 7 days in accordance with ASTM D570: 1 percent, maximum.

n. Volume resistivity, tested in accordance with ASTM D257: 1×10^{12} Ω·cm minimum.

o. Bond strength, tested in accordance with ASTM C882: 2,000 psi.

p. Shrinkage, tested in accordance with ASTM C883: No shrinkage allowed.

2.06 FILTER FABRIC

A. Filter fabric for use with the ballast material shall conform to the requirements for filter fabric for underdrains in Section 88 of the Standard Specifications.

2.07 BUMPING POST

A. Existing bumping posts shall be salvaged and relocated as specified in Section 34 01 23, "Track Removal and Salvage."

B. New bumping posts shall have the following requirements:

1. Energy absorbing and capable of withstanding a minimum striking force of 60,024 pounds.

2. The striking face shall engage with VTA's light rail vehicle anticlimber.

3. Shall clear the VTA's light rail coupler regardless of its position.

4. Shall be bolted to the running rails. Front anchoring of the bumping post is required per the manufacturer's recommendations. The Contractor shall submit a work plan detailing front anchor and anchoring system for review and approval by VTA. The bumping post assembly shall not extend more than two inches below the base of rail.

2.08 RESTRAINING RAIL

A. Restraining rail shall consist of high strength 115RE rail as described in Section 34 11 13, Running Rails, with a part of the base cut off. Base planning shall provide a minimum clearance of one inch between rail bases.

B. Restraining rail shall be provided in the longest allowable pre-curved sections. All 115RE rail track having a centerline radius of less than or equal to 400 feet shall have restraining rail added to the inside running rail as indicated on the drawings. The minimum length of bolted restraining rail, except end approach section, shall be 21 feet. The maximum length for shipping shall be 39 feet.

C. Restraining Rail shall be designed, fabricated and shop assembled with the matching inside running rail.

D. All restraining rails shall be drilled at ends for joint bars and reinforcing bar. Joints in restraining rails shall be offset longitudinally from joint in the running rail by a minimum of 5 feet except where they connect to a frog casting. Restraining rails shall not be welded to adjoining rails.

E. The Contractor shall prepare shop drawings for the restraining rail to show complete details of the location of rail fasteners beneath the assembled restraining rail and running rail. The shop drawings shall show the spacing of restraining rail and separator blocks will not create interference between the separator block bolts and the spring clips on the rail fastener assemblies. Running rails and restraining rails shall be furnished in lengths such that separator blocks will not be located within 6 inches of a field weld in the running rail and that field welded joints in the running rail will not be located at rail fastener locations.

F. All separator and end block shall be bolted with heat treated bolts with lock nuts and spring washers. Restraining rail and matching pre-curved running rail shall be shop drilled for separator blocks. Drilled holes shall be ground to remove all sharp edges. Upset rail branding shall be ground flush in all separator block areas.

G. Rails shall be machined, cut and drilled but not flame or torch cut.

H. Restraining Rail Separator Blocks

1. 4-inch separator blocks for the restraining rail shall be spaced as shown on the Contract Drawings. 12-inch end blocks shall be at every restraining rail joint and at each end of restraining rail.

2. Separator and end blocks, and shims, shall conform to ASTM A36.

3. Separator and end blocks shall conform to the dimensions and bolt hole locations as shown on the Contract Drawings.

4. Separator and end block shims shall be fabricated to a configuration to match the separator and end blocks, and as shown on the Contract Drawings. Shims shall be provided to adjust flangeway width as shown on the Contract Drawings.

I. Mounting Hardware and Other Components

1. Restraining rail mounting bolts shall be square head with a hold for a cotter pin. Nuts shall be castellated hex nuts.

2. Joints in restraining rail shall be standard 115RE joint bars on the side of the restraining rail closest to the centerline of track and rolled steel "D" bar on the side facing the running rail.

3. Bolts shall be ASTM F3125, ASTM A449, SAE Grade 5 or equivalent. Threads shall be UNC, 2A and 2B. Bolts shall be of the diameters and lengths as developed by the Contractor and meeting the following additional requirements:

   a. Bolts for standard joint shall be square head with hex nuts and spring washers. Spring washers shall be in accordance with the AREMA Manual, Chapter 4, Section 3.6, "Specifications for Spring Washers".

   b. Bolts for insulated joints shall be hex head with flat washers and oval lock hex nuts.

4. Additional requirements for Insulated Joints:

   a. Insulated joints shall be provided in restraining rail where the running rail contains insulated joints. The electrical properties of the complete insulated joints shall be per Article 2.02, Bonded Insulated Joints, provided herein.

2.09 SHOP QUALITY CONTROL

A. Before shipment, 1 crossing panel of each type shall be completely assembled in Contractor's fabrication shop for inspection by Contractor's representative. All costs associated with transportation, meals, and boarding for Contractor's inspection team will be at Contractor's expense.

B. Contractor's representative will make a maximum of one trip to inspect the crossing panels and its associated processes. Contractor shall notify VTA at least 24 hours before the assembly inspection. It is expected that Contractor's representatives will spend a full 8-hour day at the shop during the inspection trip. Contractor shall provide representatives with safe access to the lay down area and assist with the inspection activities as required.

2.10 TRACK INSPECTION TOOLS

A. Inspection tools shall be furnished by Contractor use by Contractor's representative for inspection and quality assurance personnel. Inspection tools shall be as specified by the recommended practices of the AREMA Manual of Railway Engineering as appropriate, or general construction industry standards. Contractor may request and obtain information on tools presently used for inspecting trackwork construction. Inspection tools shall be provided by the Contractor at their sole cost and part of the work specified herein.

1. Three rail thermometers shall be railroad industry standard with magnetic back, enclosed face, temperature range of approximately 0ºF to 160ºF, and of durable construction. Glass thermometer core is not acceptable.

2. Three 36 inch straightedges for inspection of rails, special trackwork and rail welds; 7/32 inch x 2-3/8 inch x 36 inch, machinist quality, with or without dimensional scales.

3. Three steel taper gauges, capable of reading in decimal units, inches and millimeters (0 inch to 5/32 inch), of machinist quality.

4. Two 2-piece combination track level and track gauge shall be railroad industry standard for track gauge 56-1/2 inch, and shall be capable of reading to accuracy of not less than +/- 1/16 inch for each function. Integral capabilities shall be provided for reading flangeway width at restraining rails, guard rails, and track frogs. Track level component shall provide range of +/- 6 in. of track cross-level provided by shock-proof spirit level. Rigid carrying case, care and use instructions, repair parts list and factory authorized source for repair and parts shall be provided for each level-gauge.

5. Two heavy-duty torque wrenches shall include torque wrench with or without multiplier, capable of reading 0 pound feet to not less than 2,800 pound feet. Torque wrench and multiplier shall use the same size square drive. Three square drive sockets of the same size as torque multiplier shall be provided for square nuts of sizes 1-1/4 inch (6-point), 1-1/2 inch (8-point), and 2 inch (8-point) Single carrying case for torque wrench, multiplier, and at least 3 sockets noted above shall be provided.

PART 3 – EXECUTION

3.01 EXECUTION

A. Superelevation tags shall be installed as specified in Section 34 11 10, "Trackwork Installation General Requirements."

B. Concrete crossing panels shall be installed on grade crossings as indicated in Section 34 11 29, "Grade and Pedestrian Crossing Track Construction."

C. Filter fabric shall be installed as indicated in Section 33 11 26, "Ballasted Primary Track Construction."

D. Installation of insulated rail joints shall be as specified in Section 34 11 26, "Ballasted Primary Track Construction."

E. Emergency guard rail shall be installed on ballasted primary track as indicated in the Plans.

F. Emergency guard rail on LRT track shall be secured to concrete cross ties with plates, rail clips, and bolts. Rail shall be drilled at each end and joined with fully bolted 4-hole joint bars.

G. Bumping post shall be relocated and installed as shown on the Plans and as specified herein,

1. Installation of bumping post shall not be undertaken by Contractor until track installation, final surfacing and alignment and final ballast dressing and consolidation have been completed to the satisfaction of VTA. Following acceptance of track and ballast installation at the location of each bumping post and following 48 hours advance notice to VTA, Contractor may proceed with installation of the bumping posts.

H. Install restraining rail as indicated on VTA Standard Drawing STW-011 and in accordance with the approved manufacturer's shop drawings.

3.02 WARRANTY

A. Contractor shall furnish, and extend to VTA, the manufacturer's warranty against all manufacturing defects in addition to Contractor's standard 1-year warranty for materials and installation.

END OF SECTION 34 11 93

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SECTION 34 21 00

TRACTION POWER GENERAL REQUIREMENTS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section covers the general requirements for the traction power system and equipment for the for the VTA Eastridge to BART Regional Connect: Capitol Expressway Light Rail Project. Work includes, but not limited to:

1. Detailed Engineering design of new Traction Power Substations (TPSS) - two 2.5 Megawatt Traction Power Substations (TPSS) TPSS #33 and TPSS #34.
2. Procurement, delivery, installation, and testing of TPSS, from interface with the local power utility to the interface to the right-of-way and the combined system ductbanks.
3. All traction power cabling, ductbanks and foundations.
4. Coordination, installation and interfaces to all communication system equipment within each TPSS.
5. Modifications to the existing substation TPSS #28.
6. Integrated testing in accordance with Contract Documents.
7. Coordination and compliance with local power utility requirements to provide power to each new traction power substation. Work includes providing equipment submittals, protection coordination studies and settings, meetings and testing.

B. Specific requirements are set forth in individual Sections of Division 34 21.

C. The substation equipment includes incoming utility termination cabinet, ac switchgear, transformer-rectifier unit, dc switchgear, auxiliary power equipment, battery, battery charger, emergency trip stations, transfer trip system, Communication Interface Cabinet, PAC equipment, and SCADA Interface and installation.

D. All substations shall have remote supervisory indication and control.

1.02 REFERENCED STANDARDS

B. The products and execution of work under Division 34 21 shall meet the requirements of the latest edition of the following codes, standards and regulations.

1. California Code of Regulations (CCR) Title 24 and other applicable local codes and ordinances

2. National Electrical Safety Code (NESC), current edition

3. CAL OSHA Low Voltage Electrical Safety Orders

4. CAL OSHA High Voltage Electrical Safety Orders

5. State of California Public Utilities Commission General Order No. 95

6. Federal, State and Local Authorities: All applicable codes and regulations

7. State of California Public Utilities Commission (Cal. PUC) G.O. 128: Rules for Construction of Underground electrical Supply and Communications Systems

8. Organization Number Title

Organization	Number	Title
ANSI/IEEE	C34.2	Semiconductor Power Rectifiers
ANSI/IEEE	C37.06	Preferred Ratings and Related Required Capabilities for Ac High-Voltage Circuit Breakers
ANSI/IEEE	C37.14	Low-Voltage Dc Power Circuit Breakers Used in Enclosures
ANSI/IEEE	C37.16	Preferred Ratings, Related Requirements, and Applications Recommendations for Low-Voltage Power Circuit Breakers
ANSI/IEEE	C37.20.1	Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear
ANSI/IEEE	C37.20.3	Standard for Metal-Enclosed Interrupter Switchgear
ANSI/IEEE	C37.46	Specifications for Power Fuses and Fuse Disconnecting Switches
ANSI/IEEE	C37.90	Relays and Relay Systems Associated with Electric Power Apparatus
ANSI/IEEE	C39.1	Requirements for Electrical Analog Indicating Instruments
ANSI/IEEE	C57.12.01	General Requirements for Dry Type Distribution and Power Transformers
ANSI/IEEE	C57.12.51	Requirements for Ventilated Dry-Type Power Transformers, 501 kVA and Larger, Three-Phase, with High-Voltage 601 to 34,500 Volts, Low-Voltage 208Y/120 to 4160 Volts

ANSI/IEEE	C57.12.91	Test Code for Dry Type Distribution and Power Transformers
ANSI/IEEE	C57.13	Standard Requirements for Instrument Transformers
ANSI/IEEE	C62.11	Standard for Metal Oxide Surge Arresters for Ac Power Circuits
ANSI	C80.1	Specifications for Rigid Steel Conduit, Zinc Coated
ASTM	A48	Standard Specification for Gray Iron Castings
ASTM	A-123	Hot-Dipped Galvanizing after Fabrication
ASTM	A153	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM	B8	Concentric Lay Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM	D635	Test for Rate of Burning and/or Extent and Time of Burning of Self Supporting Plastics in a Horizontal Position
IEEE	1	Standard General Principles for Temperature limits in the Rating of Electrical Equipment and for the Evaluation of Electrical Insulation
IEEE	943	Guide for Aging Mechanisms and Diagnostic Procedures in Evaluating Electrical Insulation Systems
IEEE	485	Recommended Practice for Sizing Large Lead Storage Batteries for Generating Stations and Substations
NFPA	70	National Electrical Code (NEC)
NEMA	AB1	Molded Case Circuit Breakers
NEMA	FB1	Fittings, Cast Metal Boxes, and conduit Bodies for Conduit and Cable Assemblies
NEMA	FG1	Fiberglass Cable Tray Systems
NEMA	ICS 6	Industrial Enclosures
NEMA	PB1	Panelboards

NEMA	PE5	Constant Potential Type Electric Utility Battery Chargers
NEMA	SK60	Silicon Rectifier Diodes and Stacks
NEMA	TC2	Electrical, Plastic Tubing (EPT) and Conduit (EPC = 40 and EPC = 80)
NEMA	TC 3	PVC Fittings for Use with Rigid PVC Conduit and Tubing
NEMA	TC6	ABS and PVC Plastic Utilities duct for Underground installation
NEMA	VE-1	Cable Tray Systems
NEMA	WC 30	Color Coding of Wires and Cables
NEMA	WC 70	Nonshielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy
NEMA	WC 71	Standard for Nonshielded Cables Rated 2001-5000 Volts for use in the Distribution of Electric Energy
UL	6	Standard For Electrical Rigid Metal Conduit – Steel
UL	50	Boxes and Enclosures
UL	83	Thermoplastic-Insulated Wires and Cables
UL	514A	Metallic Outlet Boxes
UL	514B	Fittings for Conduit and Outlet Boxes
UL	514C	Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL	1059	Terminal Blocks
PG&E	Green Book	Electric & Gas Service Requirements (TD-7001M) (2017-2018)
		Bulletin TD-2999B – Technical Requirements for Electric Service Interconnection at Primary Distribution Voltages

1.03 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of Section 01 33 00.

B. Provide for engineer review a list of all proposed electrical and traction power equipment and shop drawing submittals (traction power contract documents required list). The content shall include all required submittals identified in all Division 34 21 specification sections.

C. Refer to the individual specification section for specific submittal requirements.

D. Submit detailed Bill of Materials (BOM) and major equipment (BOM) for approval.

E. Bill of Materials (BOM) shall be in excel format.

F. Submit required annual inspection procedures for all Traction Power equipment.

G. For all submitted drawings:
   1. Include Table of Contents.
   2. Bind in one 11 by 17-inch volume.
   3. As required by these specifications design Packages, calculations or reports shall bear the seal of a Professional Engineer registered in the State of California, qualified by experience, who personally supervised the preparation of the Contractor's TPSS submittals.

H. Utility Power Company submittals in accordance with Bulletin TD-2999B – Technical Requirements for Electric Service Interconnection at Primary Distribution Voltages. Refer to Appendix A of this section for an extract of the submittal requirements from this PG&E document.

1.04 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed thereafter.

1.05 QUALITY CONTROL

Refer to General Conditions GC-47, Quality Assurance Program for general requirements and procedures.

1.06 QUALITY ASSURANCE

All substation equipment shall either be listed or labeled to UL standards by a nationally recognized laboratory such as Underwriter's Laboratory, or be certified as complying with UL standards by a testing agency recognized by the California Department of Labor & Industries and local jurisdiction.

1.07 GENERAL REQUIREMENTS FOR TRACTION POWERSUBSTATIONS

A. Like substation equipment shall be identical including wiring conduit cabling and fully interchangeable without modification.

B. The proposed substation building must fit the foundation as shown in Contract Drawings.

C. The design of the equipment shall provide features for the safety of personnel during operation, maintenance, and repair.

D. All equipment and materials supplied by the Contractor shall be new, of recent manufacture and of highest grade as specified. They shall be resistant to moisture and corrosion to withstand their environment and operational conditions with minimum maintenance and long life.

E. Wherever practicable, all major electrical equipment and materials furnished under this Contract shall be the product of a single manufacturer. In the case of major items, the manufacturer shall maintain a service organization within a reasonable distance from the project which is properly staffed and equipped to make repairs as required.

F. Materials and equipment shall be essentially the products of a manufacturer regularly engaged in the manufacturing of the product and the manufacturer shall have such products of comparable capacity and function to that specified in satisfactory use on a light rail transit system.

1.08 EQUIPMENT ENVIRONMENT

A. The substation sites are located at approximately sea level with a normal barometric pressure of 29.21 inches Hg. Outdoor temperatures in the San Jose area range approximately from plus 35°F to plus 92°F.

B. The atmosphere in San Jose has a combination of industrial pollutants expected of a metropolitan area with a concentration of various types of industries.

1.09 SEISMIC CALCULATIONS

All equipment provided in this Contract shall be suitable for the seismic conditions specified in the Contract Documents. Suitable bracing and an adequate means for anchorage designed and sealed by a registered structural engineer in the State of California shall be provided in accordance with the seismic requirements stated herein. Calculations shall be submitted according to the requirements of Contract Documents.

1.10 GENERAL REQUIREMENTS FOR TRACTION POWER SUBSTATION CONTROL SYSTEM

The substation control and monitoring shall be accomplished using microprocessor controlled devices and programmable automation controller (PAC). Ac and dc protective relays shall be multi-function, microprocessor based relays. PACs shall be used as to perform the functions described in Section 34 21 71 and shall comply with the articles of Section 34 21 18 – Microprocessor Controlled Devices and Programmable Automation Controllers.

1.11 SCADA

Each Traction Power Substation will be equipped with a Communication Interface Cabinet (CIC) with designated terminals for interfacing with the SCADA system. Specific HMI/SCADA requirements and points are detailed in Section 34 21 17 – HMI and SCADA Interface Requirements.

1.12 GENERAL SAFETY REQUIREMENTS

A. Traction Electrification Hazard Analysis

Submit an analysis report stamped and sealed by a professional electrical engineer registered in the state of California as follows.

The Contractor shall perform a Hazard Analysis of the Traction Electrification System, for the following components, systems, and subsystems:

1. Overhead contact system, including high voltage switches, and feeders.

2. Traction power substations, including but not limited to the major components, including traction power transformer, auxiliary power transformer, ac switchgear, dc switchgear, controls and control power, rectifier, high voltage switches, electrical devices, and ac and dc protective devices.

3. The analysis shall include the following hazards arising from both normal and abnormal operation, including human error:

   a. Bolted fault on the ac switchgear primary power bus, on both the line and load side of the circuit breaker.

   b. Bolted fault on the secondary of the traction power transformer.

   c. Arcing fault and bolted fault on the dc switchgear bus to equipment enclosure.

   d. OCS conductor to ground fault.

e. OCS conductor to rail fault.

f. OCS conductor to pole fault.

g. Complete loss of utility power, loss of phase, undervoltage.

h. Restoration of utility power.

i. Lightning strike.

j. Unauthorized entry of substation or equipment enclosures.

k. Loss of ventilation.

l. Control system failure, including devices and protective device.

4. The analysis shall demonstrate that all identified hazards are either eliminated or reduced to levels of risk acceptable to VTA. The hazard analysis shall be adjusted or amended as the system design and construction progresses.

5. The analysis methods shall be selected by the Contractor as appropriate for the system and the Category of hazard severity, subject to approval by VTA.

6. Hazards of Categories I and II severity shall receive analyses sufficiently rigorous to demonstrate that the hazard cannot occur, or the associated risk is reduced to a level acceptable to VTA.

7. The Contractor shall be prepared to demonstrate by test the validity of any portion of all analyses of Categories I and II severity hazards at the request of VTA.

8. Published failure rates for components shall be utilized wherever possible.

9. Existing hazard analyses of like equipment operating under like conditions may be offered in lieu of performing a complete analysis of proposed equipment, subject to VTA approval.

B. Arc Flash Hazard Analysis

Submit an analysis report stamped and sealed by a professional electrical engineer registered in the state of California as follows.

1. Perform Arc-Flash Hazard Analysis with the aid of computer software.

2. Perform analysis in conjunction with the short-circuit and coordination studies.

3. Submit the results of the analysis in a table and include device or bus identification tag, bolted fault and arcing fault current levels, flash protection boundary, distances, personal protective equipment classes and arc-flash incident energy levels.

4. Perform the analysis under worst-case arc fault conditions, and describe in the final report when applicable, how these conditions differ from worst-case bolted fault conditions.

5. Arc flash analysis for the AC system shall be performed in accordance with IEEE 1584 and provide results as required by NFPA 70E.

6. Arc flash analysis for the DC system shall be in accordance with NFPA 70E

7. Provide self-adhesive equipment labels incompliance with ANSI Z535.4 to document arc flash hazard and required personal protective equipment.

C. AC System Coordination Study

1. Submit an AC coordination study stamped and sealed by a professional electrical engineer registered in the state of California in accordance with the requirements of specification 34 21 19.

2. Contractor shall provide up to two studies and system settings in order to accommodate utility power from two alternate power sources.

3. Study shall provide relay protective settings and all relay setting parameters.

D. DC System Coordination Study

Submit a DC coordination study stamped and sealed by a professional electrical engineer registered in the state of California in accordance with the requirements of specification 34 21 20. Study shall provide relay protective settings and all relay setting parameters.

PART 2 – PRODUCTS – NOT USED

PART 3 – EXECUTION – NOT USED

END OF SECTION 34 21 00

APPENDIX A

Extracted from Bulletin TD-2999B – Technical Requirements for Electric Service Interconnection at Primary Distribution Voltages

UTILITY (PG&E) COORDINATION REQUIREMENTS

A. The following shall be submitted to PG&E (via the Project) for acceptance / approval:

1. Single Line diagrams
2. Meter and Relay diagrams
3. Three-Line diagrams of the required protection device
4. Control diagrams including direct current (dc) tripping circuit
5. Proposed relay specifications and settings
6. Relay manufacturer, model, style, type, ranges, settings, and a copy of the relay instruction manual
7. Projected electrical demand (i.e. kilowatt [kW]), including the following information:
   a. Power factor
   b. Load factor
   c. Large motor sizes
   d. Motor starting currents
   e. Customer Transformer sizes
   f. Estimated breakdown of electric energy use (i.e., kilowatt hours [kwh]) by month
8. Full-size phase and ground coordination curves showing full coordination with the local utility system. A registered electrical engineer must prepare and stamp the fault-study results.
9. Maintenance program documentation for PG&E required switches, interrupting devices, and protective equipment.

B. The following shall be submitted to PG&E for the battery system for approval:

10. Type of Battery (Vented Lead Acid-VLA or NiCd). Monoblock (multiples cells in a jar) batteries from C & D, EnerSys or other vendors will be acceptable. Battery racks must be designed to withstand loading based on IEEE 693 (High Seismic).

11. Detail information of load including continuous and momentary. No minimum load requirement- Smallest flooded acid may be the limitation

12. Battery sizing calculation based on IEEE Standard 485-2010 (IEEE recommended Practice for Sizing Large Lead Storage Batteries for Generating Stations and Substations) or IEEE Standard 1115-2014 (IEEE recommended Practice for Sizing Nickel-Cadmium Batteries for Stationary application) and minimum 8 hours discharge rate using manufacturer software (to ensure proper discharge curve is used) using aging factor of 1.25 and design margin of 1.1 to be clearly shown on the calculation. Charger sizing calculation based on battery size with recharge time of 12 hours assuming charger will support the continuous load as well as recharges the battery at the same time.

13. When battery is installed proof of three (3) hour discharge testing to ensure battery has the capacity to support the load and trip; per IEEE Standard 450-2010 (Voltage measurements should be taken every 15 minutes throughout the testing).

14. Documentation showing what kind of maintenance will be done (Monthly, Quarterly, and Yearly etc).

15. Monitoring of minimum battery low voltage by separate voltage relay or through charger and provide critical alarm to SCADA or monitoring system.

16. Along with documentation of items 1-5; See Attachment 1, Third Party Interconnection Battery Information Sheet and Acceptance Document, located on pages 23 and 24 (Technical Bulletin TD-2999B-030). This information must be completed and submitted by the customer to Substation Project Engineering Department for approval.

SECTION 34 21 01

TRACTION POWER BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section covers the basic electrical materials and methods for the manufacturing of two 2.5 megawatt Traction Power Substations (TPSS) TPSS #33 and TPSS #34 and the pad-mounted DC feeder disconnect and bypass switches at TPSS #33 and #34. Specific requirements are set forth in individual Sections of Division 34 21.

B. The substation equipment includes incoming utility termination cabinet, ac switchgear, transformer-rectifier unit, dc switchgear, auxiliary power equipment, battery, battery charger, Communication Interface Cabinet, PAC equipment, HMI, and SCADA Interface and installation.

C. All substations shall have remote supervisory indication and control.

1.02 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of Section 01 33 00.

B. Refer to the individual specification section for specific submittal requirements. Submit detailed Bill of Materials (BOM) and major equipment (BOM) for approval.

C. Bill of Materials (BOM) shall be in excel format.

1.03 QUALITY CONTROL

Refer to General Conditions GC-47, Quality Assurance Program for general requirements and procedures.

1.04 QUALITY ASSURANCE

All substation equipment shall either be listed or labeled to UL standards by a nationally recognized laboratory such as Underwriter’s Laboratory, or be certified as complying with UL standards by a testing agency recognized by the California Department of Labor & Industries and local jurisdiction.

1.05 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed thereafter.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Items of any one classification shall be products of one manufacturer.

B. Materials shall be new, free of defects and of current manufacture. Do not reuse existing materials.

2.02 CONDUIT FITTINGS

Include those items used with conduit to form conduit runs. Use fittings with the type of conduit for which they are designed, i.e.; use liquid-tight fittings with liquid-tight conduit. Liquid-tight fittings shall have an insulated throat. Fittings shall be by O.Z. Gedney, Carlon, T&B, or approved equal.

2.03 CONDUIT SUPPORTS

A. Conduit clamp backs shall be of the nesting one-hole type, hot-dip galvanized malleable or cast iron; nest back spacers shall be of similar material and finish. Use clamp backs with one-hole malleable-iron hot-dip galvanized pipe straps. Steel straps shall be one- hole, ribbed, snap-type, zinc-plated. Clamps, spacers and straps shall be by O.Z. Gedney, or approved equal.

B. Framing channel shall be hot-dip galvanized. Framing channel and associated conduit clamps shall be by Unistrut, or approved equal.

C. Concrete fasteners and screws shall be stainless steel or zinc-plated.

2.04 RELAYS

A. Relays shall be utility grade, and be immune from inadvertent operation due to ambient EMI, including radio frequency signals. Relays shall be designed, constructed, and tested in accordance with the applicable provisions of ANSI C37.90.

B. Auxiliary relays shall be provided where required or specified and shall be easily accessible for removal or maintenance. Plug-in style auxiliary relays shall be provided with stainless steel hold-down spring clips. All auxiliary relays shall be UL approved.

C. Contact current ratings shall be based on continuous, inrush, or interrupting requirements for the duty category as defined by IEC 60512-15-8 Ed. 1.0 b:1995, whichever is worse, and then derated by at least a factor of four. Contacts shall be rated for twice the applied voltage, minimum.

D. Contact materials shall be selected for the actual loads, and not solely on the device rating. Silver bifurcated contacts and gold alloy bifurcated cross bar contacts are preferred on low level and dry circuits, respectively.

E. Lockout relays shall be hand-reset by a heavy-duty switchboard type pistol-grip handle.

F. The coils of all devices shall be suppressed except where performance may be affected.

G. Unsuppressed coils are permitted only with the explicit approval of VTA.

H. All relays except for multi-function microprocessor-controlled relays shall have a guaranteed mechanical service life of at least 30 years.

I. There shall be a maximum of two wire terminations on any relay or contactor terminal.

J. All relays and contactors shall be mounted and oriented as recommended by the supplier.

2.05 SEALING COMPOUND

A two-part silicone foam to prevent passage of fire, smoke, toxic gases and water shall be provided. Sealing compound shall be UL 1479 listed. Approved products include.

1. Dow Corning 3-6548 Silicone RTV Foam, as manufactured by Dow Corning Corporation, Midland, Michigan 48640; or

2. Chase-Foam, CTC PR-855, as manufactured by Chase Technology Corporation, 168 Railroad Street, Huntington Station, New York 11746.

2.06 SWITCHES AND INDICATORS

A. Control, selector, and instrument switches shall be of the heavy-duty rotary type. Switches shall have silver-to-silver contacts and utilize a cam action or similar positive means for actuating contacts. All contacts shall be enclosed with easily removable covers. All switches shall have escutcheon plates. Each controllable device shall have a separate control switch.

B. Contact current ratings shall be based on continuous, inrush, or interrupting requirements for the duty category as defined by IEC standard, whichever is worse, and then derated by at least a factor of four. Contacts shall be rated for twice the applied voltage, minimum.

C. Breaker and lockout control switches shall have heavy-duty pistol-grip handles and operation targets. Breaker switch positions shall be “OPEN” and ‘CLOSE” with a spring return to center. Lockout switch positions shall be “LOCKOUT” and “RESET” with a spring return to center. “OPEN” and “CLOSED” position indicating lights shall be provided. All illuminated red lights shall indicate the respective breaker is in the closed position. Amber lights shall be used for the Lockout relay reset position. All illuminated green lights shall indicate the respective breaker is in the open position or the lockout relay is tripped.

D. Each substation shall be provided with a control selector switch with “LOCAL” and “REMOTE” positions and the following indications:

1. White light – “LOCAL” position
2. Blue light – “REMOTE’ position
3. LOCAL/ REMOTE position shall also be annunciated at the HMI and via SCADA.

E. All indicating lights shall be long life high brightness and utilize LED arrays and integral current limiting resistors. LEDs used on the switchgear sections shall be on the same manufacturer and model. All indicators shall be selected to permit maximum visibility in direct sunlight from all viewing angles. LEDs shall be approved by VTA prior to use in the manufacture of the switchgear.

F. All switch bodies shall be keyed to prevent rotation. All mounting hardware, including the body portion extending through the panel, shall be metal.

G. There shall be a maximum of two wires connected to each switch terminal.

2.07 CONNECTIONS AND TERMINATIONS

A. Make connections only at terminals on the devices, on terminal blocks, or the ground bus. Make no splices or taps between these terminal points. Make connections for wiring using ring-type compression connectors with insulated compression sleeves using only manufacturer recommended tools. The insulated sleeve shall firmly grip the wire insulation and the metallic portion shall firmly grip the strands of the conductors. All control, metering, and relaying circuits requiring external connections and all unused terminals on auxiliary contacts, devices, relays, instrument transformers, and control switches shall be wired to conveniently located terminal blocks having washer head screw-type terminals, circuit-marking strips, and phenolic-laminated dust covers. Provide shorting-type terminal blocks for current-transformer connections. All 800 V dc circuits shall be brought out to separate terminal blocks mounted on at least two separate standoff insulators with a special cover, opposite polarity shall be separated and specially guarded.

B. Provide separate terminal blocks for low voltage ac, and 800 V dc circuits. Provide a minimum of ten percent spare terminals, but no less than four terminals, on each terminal block. FAST (Fast Accessible Safe Termination) installation system is not acceptable.

C. Terminal blocks for 800 V dc circuit shall be rated for 1,000 V dc and shall have marking strips for wire identification. Provide spacing of 1.5 inches between terminals. Identify all internal wiring with the Contractor's wire number at each termination by means of a suitable plastic black marking on a matte surface. Each terminal block and device shall have its own unique numbers and or letters for identification. Use each terminal block and device designation only once in the substations. Wires connected to terminal blocks and devices shall have wire numbers and or letters indicating the terminal block or device the wire is coming from and going to. Tags relying upon adhesive or taped on markers will not be acceptable. Submit type of marking strips, wire labeling and numbering scheme to VTA for approval.

D. Control and instrument wiring within high-voltage and 800 Vdc compartments shall have protective covering. The interconnecting wires between cubicles, including the common potential and control buses shall be continuous and shall terminate at terminal blocks.

E. Install wiring and cables that pass-through cubicles or work areas in suitable raceways. Wires connecting identical function devices shall have identically colored wires. Follow NEMA Standard WC 30.

F. Layout and location of devices and wiring of like units shall be identical.

G. Conveniently locate devices requiring regular calibration, resetting or operation within easy reach of personnel.

H. Control circuits and wiring requiring position indications of circuit breakers or disconnect switches shall be wired directly from auxiliary contacts operated by the circuit breaker or disconnect switch mechanism. Auxiliary relays to monitor position indication of circuit breakers or disconnect switches are not acceptable.

I. Terminal blocks shall comply with NEMA ICS 4 and shall be UL 1059 listed.

2.08 RADIO FREQUENCY INTERFERENCE

Design all substation equipment, protective relays meters, instruments and devices to minimize the radio frequency generated and to be immune from inadvertent operation by ambient radio frequency signals.

2.09 LIGHTING

The interior of equipment enclosures shall be provided with 120 Vac LED lamps, and locally switched. An isolation transformer shall be utilized for both rectifier and dc switchgear lighting. Control compartment inside other equipment enclosure shall be provided with LED strip lights and they shall be activated when the compartment door is opened.

2.10 WIRING DEVICES

A. Provide 20 amp industrial rated switches and receptacles. Heavy duty covers on outdoor receptacles shall be provided.

B. Provide brushed stainless steel covers over all wiring devices.

C. Provide 20 amp industrial rated GFCI duplex receptacles in accordance with NFPA 70 and as indicated.

2.11 NAMEPLATES

A. Each item of equipment in the Substation shall be provided with a nameplate. Nameplates shall be provided in accordance with individual specification section or references cited therein, where required. All other equipment and associated control and metering devices shall be provided with nameplates as described in this Section.

B. The nameplates shall be opaque white over black laminated melamine, not less than 3/32 inches thick. The nameplates shall have black engraved letters and shall comply with FS L-P-387A, Type NDP. Equipment nameplates shall be 1-5/8 inches high characters minimum. Device nameplates shall be 5/8 inches high and have ¼ inch high characters. The nameplates shall be fastened to the equipment or device enclosure door with stainless steel machine screws. Other equipment nameplates shall be sized and lettered according to the equipment and application as approved by VTA.

PART 3 - EXECUTION

3.01 COMPONENT IDENTIFICATION AND SERIAL NUMBERS

A. All equipment shall be permanently identified with the supplier's name, part number, and revision level. Identification shall be by engraved metal labels riveted in place or other approved permanent method. Adhesive attached labels are prohibited.

B. In addition, the Contractor shall assign discrete serial numbers to certain equipment specified in this Section. Serial numbers shall be in sequential, numerical order for the total quantity of each component, including spares.

C. All serial numbers shall be subject to VTA's approval. Components shall be re-serialized by the original supplier upon request by VTA. Duplicate serial numbers shall not be used within the type or model.

D. Serial numbers of all components shall be presented to VTA as each portion of the installation is completed or when spare components are received. The Contractor shall track all serial number transfers and prepare a list of all serial numbered apparatus installed in each substation for inclusion in the substation history book.

E. At a minimum, the following equipment shall have serial numbers applied:

1. AC Breaker
2. Rectifier Transformer
3. Rectifier Assemblies
4. Interphase Transformers
5. DC Main Breaker
6. DC Feeder Breakers
7. Auxiliary Power Transformer
8. All Electronic Cards
9. All Enclosures
10. Disconnect and Bypass Switches
11. AC Panelboard
12. DC Panelboard

3.02 SEALING COMPOUND

Sealing compound shall be installed in accordance with the manufacturer's written instructions.

3.03 INSTALLATION

Refer to section 34 21 16 – Traction Power Substations and section 34 21 53 Traction Power Substation Field Installation.

END OF SECTION 34 21 01

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SECTION 34 21 15

TRACTION POWER SUBSTATION AUXILIARY POWER

PART 1 - GENERAL

1.01 SUMMARY

This Section describes the requirements for the design, furnishing, and installing of the auxiliary power for the new traction power substations.

This section supplements and provides addition requirements in addition to those listed in Section 34 21 16 – Traction Power Substations.

1.02 REFERENCE STANDARDS

Organization	Number	Title
ANSI/IEEE	485	Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications
NEMA	250	Enclosures for Electrical Equipment (1,000 Volts Maximum)
NEMA	AB1	Molded-Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures
NEMA	FU1	Low Voltage Cartridge Fuses
NEMA	PB1	Panelboards
NEMA	PE5	Utility Type Battery Chargers
UL	50	Cabinets and Boxes
UL	67	Panelboards

1.03 SUBMITTALS

A. Refer to Section 01 33 00 – Submittals.

B. Submit the following for VTA's approval:

1. Overall drawings of the auxiliary power equipment consisting of:

a. Dimensions and weights

b. Plan views

c. Elevation views

d. Sections

2. Equipment control schematic and wiring diagrams.

3. Panelboard shop drawings.

4. Technical data and catalog sheets on all devices, equipment, and materials.

5. Engineering calculations for battery sizing.

6. Engineering calculations for the required ratings of the dc service panelboard and the station service panelboard.

1.04 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed thereafter.

1.05 QUALITY CONTROL

Refer to General Conditions GC-47, Quality Assurance Program, for general requirements and procedures.

1.06 QUALITY ASSURANCE

The auxiliary power equipment, including battery charger, disconnects, panelboards, fuses, and miscellaneous equipment, shall be UL labeled or certified as conforming to the requirements of UL and ANSI by an Independent Testing Laboratory recognized by the State of California.

PART 2 - PRODUCTS

2.01 DC CONTROL POWER

A. The dc control power voltage shall be 125 Vdc.

B. The dc control power system shall consist of a battery charger, batteries, battery racks, fused disconnect switch, and accessories which shall provide control power for the substation equipment at each location.

C. The system shall be electrically isolated from ground, except for a single point connection to the ac ground bus for the dc control power return circuit.

D. The battery and its associated charger shall be connected in parallel.

E. The charger shall carry the continuous load of the substation in addition to charging the battery.

F. The battery may supply heavy short-term current demands. When the ac supply power to the charger is interrupted, the battery shall supply all the required power for the specified load duty cycle.

2.02 BATTERIES

A. The batteries shall be designed to provide 20 years of float service under normal usage for the intended duty cycle.

B. The batteries shall be low maintenance, heavy-duty, lead acid, valve regulated, vented, and listed by UL. Contractor may offer equivalent lead-selenium or lead-calcium batteries for stationary power. Batteries shall be acceptable to the local utility company.

C. The battery capacity shall be sized in accordance with IEEE 485 and shall provide rated ampere-hours for a 10-hour discharge rate. Load and battery sizing calculations shall be submitted per 1.05. Battery discharge test shall be conducted in accordance with NEMA PE 5 and IEEE 450 as per 26 60 04-3.01.

D. The battery capacity shall be based on the following load duty cycle over a period of 10 <u>hours at 40°C ambient from a fully charged state</u> with the battery charger out of service:

Substation	In full operation
After 10 hours	Close and trip one high-voltage ac circuit breaker
After 10 hours	Close and trip sequentially, all the 800 Vdc circuit breakers

E. The batteries shall be vented, leak proof, and shall consist of individual cells in molded cases for durability and high impact resistant.

F. The batteries shall be provided with a pressure relief valve that shall not permit the release of gas during normal charging.

G. Batteries shall be connected together into a battery bank using tin-plated or silver-plated solid copper bus bar, silicon bronze bolts, nuts, and fasteners. Cable jumpers are not permitted for the battery connection.

H. The batteries shall not be capable of explosion under any condition, including a short circuit discharge.

I. The cabinet or rack shall be dead front, corrosion resistant, and shall completely enclose the batteries.

J. The batteries shall be replaceable individually and shall be accessible for maintenance, without disassembling the entire battery bank or stack.

K. Each battery bank shall be provided with a stainless steel nameplate. The nameplate shall provide the following information:

1. Manufacturer’s name
2. Month and year of manufacture
3. One minute, one hour, and eight hour ampere rating

L. The battery shall be warranted to be free from defects in materials and workmanship for five years and warranted to have at least 80 percent of its rated capacity for 15 years from the date of acceptance of the equipment.

M. Batteries shall be rated to supply the voltage necessary to close and trip all electrically operated ac and dc circuit breakers.

N. Battery containers shall be heat-resistant, plastic flame retardant, ABS L.O.1 greater than 28, and not deteriorate.

O. Cell covers shall be cemented in place to provide a permanent leak-proof seal.

P. Cell terminal posts shall be compression rubber bushing, epoxy sealed, and permanently identified.

Q. Provide Hydrogen sensor to activate alarm at 1% and activate the exhaust fan at 2%.

2.03 BATTERY CHARGER

A. The battery charger shall be completely automatic, fully regulated, two stages, silicon-controlled-rectifier type and shall comply with NEMA PE5, except as modified herein. The battery charger shall have sufficient capacity to support all normal loads in the substation and simultaneously recharge the batteries from 1.75 volts per cell to 85% of battery capacity within eight hours. The battery charger shall be cooled by natural air convection.

B. The battery charger enclosure shall be NEMA 250, Type 12. The enclosure shall be provided with a hinged front panel and a minimum of two latches.

C. The output voltage shall provide a float charge cell voltage in accordance with the battery manufacturer's recommendation. The battery charger output float voltage shall be regulated to $\pm$2% with a $\pm$10% variation in the ac supply voltage.

D. The audible noise level of the battery charger shall be less than 55 dbA measured in accordance with NEMA PE5.

E. For fault conditions of very low load resistance, such as a dead short, the battery charger shall ("fold-back") limit both the output current and voltage.

F. The current limit shall be factory preset to provide the capacity described above and shall be field adjustable from 90% to 110% of the factory preset value. Normal operation shall automatically resume when the overload or short circuit is removed. In addition, a two- pole output circuit breaker shall be provided.

G. The battery charger shall be powered by 120 or 240 volts ac single-phase, 60 Hz from the ac panelboard. Electrical isolation shall be provided between the input and output.

H. Each battery charger shall be furnished with an output voltmeter and an output ammeter. The meters shall be 3-1/2 digit LED or LCD type, panel-mounted units accurate to 1% of the full-scale reading and shall be mounted to the charger enclosure front panel.

I. Ground fault protection shall be provided on the battery charger output by verifying that the positive and negative return currents sum to zero. The sensitivity of the ground fault protection shall be field adjustable to eliminate nuisance trips. This protection shall shunt trip the charger output circuit breaker.

J. The battery charger shall provide both local and remote annunciation in the event of battery charger failure. At minimum, the following failures shall be detected and annunciated as a battery charger failure:

1. Loss of the ac input supply

2. Loss of the dc output

3. Ground fault

K. Battery Charger shall be equipped with the following:

1. Ac power “ON” pilot light

2. 24-hour high rate timer

3. Float and high rate charge voltage adjusting potentiometers

4. Ac failure alarm relay and indicator light

5. Surge and transient protection

6. Ground detector relay and indicator light

7. Dc high-low voltage alarm relay and indicator light

2.04 BATTERY RACKS

A. Battery racks shall be two tier or two step, constructed of steel channels.

B. Racks shall be finish painted with at least two coats of alkaline resistant gray paint.

C. Steel channels shall be equipped with plastic insulation channels, arranged to fit snugly over the steel channels to insulate the cells from the steel racks.

D. Plastic material shall have the dielectric strength to resist deterioration from battery electrolytes.

E. Battery rack anchorage shall be designed for the specified seismic zone in accordance with the latest California Building Code.

2.05 FUSED DISCONNECT SWITCH

A. A two pole fused load break disconnect switch shall be provided to permit isolation of the battery from the loads and battery charger. The fuse rating and switch size shall be coordinated with the dc circuit breaker in the battery charger. The disconnect switch and fuse shall be mounted in a NEMA Type 1 enclosure adjacent to the batteries and supplied with an external handle for operation.

B. The fuses shall comply with NEMA FU1 and shall provide overcurrent and short circuit protection for the battery and the main cables to the dc distribution panelboard.

2.06 EYE WASH STATION

A portable eye wash with 10 gallons of water shall be provided at each substation.

2.07 ACCESSORIES

Accessories for normal operation and maintenance of batteries shall be furnished for each battery and shall include the following:

1. One cell lifting sling complete with strap and spreader bar
2. One battery log book
3. One quart of terminal grease
4. One set of special tools for maintenance, including torque wrench
5. One set of cell identification numbers

2.08 DC SERVICE PANELBOARD

A. The dc panelboard shall comply with the requirements of NEMA PB 1 and shall be certified to UL 67.

B. The panelboard shall be designed for two wire, 125 Vdc ungrounded power distribution service.

C. The panelboard shall be provided with main and branch circuit breakers complying with NEMA AB 1.

D. The panelboard shall be a surface mounted, dead-front type, housed in a NEMA 1 steel enclosure, with a hinged front cover and a minimum of two latches.

E. The inside face of the cover shall be provided with a circuit directory.

F. The panelboard bus shall be copper and the current density shall be limited to 1,000 A per square inch. A separate copper ground bus, with a full rating shall be provided.

G. The panelboard shall be furnished with a main breaker and incoming terminals for separate connection of the batteries and battery charger.

H. The branch circuit breakers shall be 2-pole and a minimum of 100 A frame size with a 10,000 A interrupting rating at 250 Vdc, minimum.

I. The trip mechanism shall be thermal-magnetic and shall be trip-free. Breaker “on”, “off” and “tripped” positions shall be clearly indicated by the handle position.

J. Main and branch circuit breakers shall be furnished with auxiliary contacts for annunciation.

K. Circuit breakers shall be bolted to the panelboard bus. Breakers that "push on" or "plug in" shall not be permitted.

L. Auxiliary contacts of the main and each branch circuit breaker shall be factory wired to a terminal strip for connection to the annunciator and supervisory circuits. Tripped or open circuit breakers shall be annunciated for local and SCADA indications.

M. The panelboard shall be furnished with the appropriate quantity of circuit breakers with a minimum of 20% spare circuit breakers.

N. Loss-of-voltage relays shall be provided as indicated on the Contract Drawings and as specified herein:

1. Dc Switchgear Control Bus

2. Ac Switchgear Control Bus

O. Loss-of-voltage relays shall be equipped with communication and contacts to be wired for local and remote annunciations.

2.09 AC STATION SERVICE PANELBOARD

A. Panelboards shall be rated 120/240 volts, single-phase, three-wire as indicated on the Contract Drawings.

B. Panelboard bus structure and main lugs or main circuit breaker shall have current ratings as shown on the Contract Drawings. Ratings shall be established by heat rise tests with maximum hot spot temperature on any connector or bus bar not to exceed 50°C rise above ambient. Factory heat rise tests shall be conducted in accordance with UL Standard 67.

C. Panelboard bus shall be copper.

D. Provide 100% current rated, insulated neutral bus.

E. Provide separate, full rated, ground bus bonded to panelboard cabinet.

F. Provide multiple lugs where conductors are shown in parallel.

G. Meet the requirements of NEMA PB 1.

H. Circuit Breakers

1. Circuit breakers shall conform to NEMA AB 1. Circuit breakers shall be

thermal magnetic trip equipped with individually insulated, braced and protected connectors. The front faces of all circuit breakers shall be flush with each other. Large permanent individual circuit numbers shall be affixed to each breaker in a uniform position. Tripped indication shall be clearly shown by the breaker handle taking a position between ON and OFF. Provisions for additional breakers shall be such that no additional connectors will be required to add breakers.

2. Circuit Breakers shall be bolted securely to the panelboard bus. "Push on" or "plug in" breakers are not acceptable.

3. Where circuit breakers are intended for switching fluorescent or HID lighting loads, they shall be rated for switching duty and labeled "SWD”.

4. Provide GFI breakers where shown on the Contract Drawings.

5. Auxiliary contacts of the main and each branch circuit breaker shall be factory wired to a terminal strip for connection to the local and SCADA indications when breakers are tripped or opened.

I. Short-circuit Rating

1. Each panelboard shall have a short circuit current rating equal to or greater than the rating shown on the Contract Drawings.

2. Short circuit rating derived by series rating through the main circuit breaker is not acceptable.

3. Panelboards shall be marked with their maximum short-circuit current ratings at the supply voltage and shall be UL listed.

J. Cabinet and Fronts

1. Panelboard assembly shall be enclosed in a steel cabinet. The rigidity and gauge of steel shall be as specified in UL Standard 50 for cabinets. The size of wiring gutters shall be in accordance with UL Standard 67 for panelboards.

2. Fronts shall include doors and have flush, stainless steel, cylinder tumbler-type locks, with latches and spring-loaded door pulls. The flush lock shall not protrude beyond the front of the door. All panelboard locks shall be keyed alike. Fronts shall have adjustable indicating trim clamps, which shall be completely concealed when the doors are closed. Doors shall be mounted by completely concealed steel hinges. Provide cabinets of sufficient dimensions to allow for future expansion and addition of circuit breakers within the panelboards, as shown on the Drawings. Panel fronts shall be of the door-in-door type such that breaker handles can be accessed by opening the inner door

and panel wiring can be accessed by opening the outer door. Provide two keys for each panel. Provide flush trims in finished areas and surface type trims in unfinished areas.

3. A circuit directory frame and card, with a transparent protective plastic covering, shall be provided on the inside of the inner door. The directory card shall provide a writing space at least ¼ inch high x 3 inches long for each circuit.

4. Fronts shall be of code gauge full finished steel, with rust-inhibiting primer and baked enamel ANSI 61 gray color finish.

5. NEMA Enclosure Type:

   a. Interior mounted cabinets shall be rated NEMA Type 1.

   b. Exterior mounted units shall be rated NEMA Type 3R unless noted otherwise.

K. Barriers

1. The panelboard interior assembly shall be dead-front with panelboard front removed.

2. Main lugs or the main circuit breaker shall be barriered on the live side.

3. The barrier in front of the main lugs shall be hinged to a fixed part of the interior.

4. The end of the bus structure opposite the mains shall be barriered.

L. Circuits and phasing shall be as shown on the Contract Documents.

M. Nameplate

1. Provide nameplates attached with screws to each panelboard front with the following information:

   a. Panel Name: ¼ inch high characters

   b. Voltage, Phase, Wire: 1/8 inch high characters

   c. Short-circuit withstand capability rating: 1/8 inch high characters

   d. Feeder Source: 1/8 inch high characters

2. Nameplate color shall be black letters on white background.

3. Nameplates shall be labeled as indicated on the Contract Drawings.

N. Provide feed-through or double lugs, where shown on the Contract Drawings, with current rating equal to the incoming feeder current rating unless otherwise shown.

O. Surge Protective Devices

1. Surge protection devices shall be provided for the Station Service.
2. Maximum continuous operating voltages of surge protective devices shall not be less than 115% of the nominal system operating voltage.
3. Surge protective devices shall be rated with an operating temperature range of minus 20 to plus 120 degrees Fahrenheit, and from 1 to 85% humidity, with no condensing.
4. Surge protective devices shall operate in altitudes up to 2,000 feet above sea level.
5. Surge protective devices shall not generate appreciable magnetic fields, i.e. sufficient fields to damage stored magnetic data.
6. Average power consumption of surge protective devices shall be 1 watt per phase or less with 0% total harmonic distortion.
7. Operating frequency range of the surge protective devices shall be 0 to 400 Hz, with a nominal system frequently of 60 Hz.
8. All surge protective devices shall be connected in parallel with the power system they are protecting. Series connected surge components shall not be used.

P. Loss-of-Voltage Relays

1. Loss-of-voltage relays shall be provided for station service power as indicated on the Contract Drawings and as specified herein.
2. The relays shall be equipped with dry contacts for local and remote annunciation.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Equipment shall be installed in accordance with Contract Documents.

B. Panelboards

1. Secure in place, plumb and square with walls, with top of cabinet at 6'-0", unless otherwise indicated. Top of cabinet and trim shall be level. Firmly anchor cabinets directly or with concealed bracing to the building structure. When panels are not located in or directly on a wall, provide a support frame of formed steel channel, which is anchored to the floor. Interiors shall not be installed until structure is totally enclosed. Where panels are mounted adjacent to each other, the top edges shall be at the same height.

2. For each branch circuit panelboard, provide a typewritten index listing each circuit in the panelboard by number with its proper load designation. Install under the transparent protective cover in the metal frame inside the cabinet door. The listing shall match circuit breaker arrangements typically with odd numbers on the left and even numbers on the right. Room numbers or names used shall be the final room numbers or names used in the building as identified on the Contract Drawings.

3. Clean and touch-up blemished surfaces with paint to match factory finish.

4. Inspect all bolted connections after installation and re-tighten all connections not securely tightened. Torque per manufacturer’s specification.

5. After construction and testing are complete, remove all debris, dust and foreign material from all panel interiors and exteriors by vacuum cleaning.

3.02 TESTING

A. Conduct inspections and perform tests to demonstrate to the satisfaction of VTA.

B. Contractor shall submit the testing methods and procedures of batteries and battery charger for approval by VTA. Record and submit the results of these tests.

C. Panelboards

1. Tests shall be performed by Contractor to verify correct circuiting, wiring, and the circuit index.

2. Each panelboard shall also be tested and pass the following tests and inspections:

a. Each panelboard shall be inspected for the correct size, rating, and the number and type of circuit breakers.

b. All connections shall be tightened to the equipment manufacturer's recommended torque.

c. The neutral bar of station service panelboard shall be grounded in accordance with the Contract Drawings.

d. Each circuit breaker shall be operated and tested for proper on-off operation.

e. Each panelboard shall have a dielectric test using a dc megger. The test should be performed by applying 1,000 Vdc for one minute between the live parts of the panelboard and the panelboard case. The one minute reading must be 100 megohms or greater for satisfactory result. Submit test data sheets to VTA for review.

3. Contractor shall correct any deficiencies as identified from above at no additional cost to VTA.

END OF SECTION 34 21 15

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SECTION 34 21 16

TRACTION POWER SUBSTATIONS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section describes the Work required to fabricate, install equipment and finish painting the prefabricated traction power substations TPSS #33 and TPSS #34.

B. Work includes the provision and installation of all traction power equipment including AC and DC Switchgear, Rectifier and rectifier transformer and all ancillary equipment, mechanical ventilation fans, backdraft dampers and appurtenances and building power, lighting and fire and intrusion systems.

1.02 REFERENCE STANDARDS

Organization	Number	Title
IEEE	C37.20.2	IEEE Standard or Metal Clad and Station-Type Cubicle Switchgear
IEEE	1	Standard General Principles for Temperature Limits in the Rating of Electric Equipment and for Evaluation of Electrical Insulation
IEEE	943	IEEE Guide for Aging Mechanisms and Diagnostic Procedures in Evaluating Electrical Insulation Systems
NEMA	ICS-6	Enclosures for Industrial Controls and Systems
NEMA	SG 5	Switchgear Power Assemblies
NFPA	72	National Fire Alarm and Signaling Code

1.03 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of Section 01 33 00, except as modified herein. Product data shall be submitted within 45 days of NTP. Calculations shall be submitted within 90 days and shop drawings shall be submitted within 120 days of NTP.

B. Submit the following engineering calculations, designs and drawings, sealed by a registered professional engineer in the State of California, and design data in accordance with the Contract Documents:

1. Structural engineering design parameters and criteria, including equipment weight and seismic criteria, deflection criteria suitable for the insulated floor, including snow, wind, and ice loading

2. Structural engineering calculations for sizing structural members, calculating maximum allowable bending, torsion and flexure during installation and transportation, sizing and design of lifting eyes under worst case conditions, including snow, wind, and ice loading

3. Structural shop drawings for fabrication including scaled floor plans, roof plans, sections, and elevation views showing penetrations for conduits, ventilation ducts, door frames, and openings

4. Structural shop drawings showing details of fabrication, including door construction and frames, removable panels, joints, welds, and bolted connections

5. Structural drawings showing anchorage of the building to the foundation

6. Detailed drawings of substation enclosure showing all equipment and accessories in place with weights, layouts, and arrangements

7. Installation procedure including methods for lifting the building with all equipment installed and lowering or jacking into place, without damage to the building or equipment installed within the building

8. Mechanical engineering calculations for sizing ventilation and heating per the specified criteria, thermal insulation calculations which design for a "U" factor of 0.27 in accordance with IEEE STD 1-2000 and 943-1986

9. Mechanical engineering shop drawings for installation and fabrication of the mechanical ventilation equipment

10. Exterior and interior lighting calculations

11. Wiring and schematic diagrams of lighting, power receptacles, heating, and ventilation equipment

12. Detailed equipment interconnection diagrams, wiring and raceway schedules

13. Cable entrance locations and cable support system plans and details

14. Enclosure and equipment grounding details, including ground grid connections

15. Shop drawings of intrusion alarm equipment:

a. Equipment layouts

b. Schematics and wiring diagrams

c. Door magnetic switch

16. Shop drawings of fire detection and alarm equipment:

a. Equipment layouts

b. Schematics and wiring diagrams

c. Smoke detector

C. Submit the following, in accordance with the Contract Documents for approval by VTA:

1. Product data and shop drawings of railings, stairways and ladders

2. Product data for paint

3. Product data for fire extinguishers

4. Substation identification:

a. Exterior substation number designation and location

b. Interior manufacturer's identification and location, if any

5. Product data for emergency trip device and knox box

6. Bill of materials for all components, indicating quantity, description and part number

7. Compliance certificates for enclosure materials and performance

8. Certified test results of thermal, electrical and acoustical insulation, including weather stripping and rain test.

1.04 MEASUREMENT AND PAYMENT

A. Measurement: Substations TPSS shall be measured by the each.

B. Payment: The contract price paid per each shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Substations TPSS complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed thereafter.

1. Payment will be made at the Contract unit price under:

a. Furnish complete 2.5 MW Traction Power Substation #33 (21 kV incoming), including building, transformer, rectifier, ac & dc switchgear, with 4 dc feeder breakers, auxiliary equipment, intrusion, fire detection, and alarm systems	EA
b. Furnish complete 2.5 MW Traction Power Substation #34 (21 kV incoming), including building, transformer, rectifier, ac & dc switchgear, with 4 dc feeder breakers, auxiliary equipment, intrusion, fire detection, and alarm systems	EA

1.05 QUALITY CONTROL

Refer to General Conditions GC-47, Quality Assurance Program for general requirements and procedures.

1.06 QUALITY ASSURANCE

A. Manufacturer of the prefabricated metal buildings shall be performed by a company regularly engaged in the production of metal buildings for prefabricated traction power substations or similar applications and as approved by VTA. Manufacturer shall have constructed at least 25 similar buildings in the last ten years. Once a manufacturer is approved, it shall not be discharged or otherwise replaced by the Contractor without the written approval of VTA.

B. Traction power buildings with same ratings must be identical in size and manufactured and constructed from approved shop drawings, unless otherwise shown on Contract Documents.

C. The personnel working on the metal buildings shall be experienced, skilled and familiar with building construction, including heating and ventilation systems.

D. Personnel must be capable of modifying the procedures specified herein to suit actual field conditions should such modifications become necessary.

E. Where engineering calculations are called out, they shall be performed by a professional engineer registered in the State of California.

F. All welding shall be performed by Certified Welders.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. The traction power substation building shall be a rain-tight, weatherproof, insulated, walk-in unit suitable for the installation and housing all Substation equipment specified herein. Rain test shall be conducted as specified in Section 34 21 63 3.3.D.

B. The equipment doors and removable covers shall meet or exceed the requirements of NEMA SG 5 and NEMA ICS-6 for weatherproof NEMA 4 enclosures.

C. Contractor shall inspect each foundation and mounting pad for proper fit prior to manufacture. Contractor is solely responsible for proper fit of all substations on foundations or pads.

D. Anchorage shall be designed to resist seismic forces in accordance with the California Building Code (CBC) requirements.

E. Galvanized rigid steel (GRS) conduits shall be used, EMT and PVC material are not allowed.

F. Copper buss shall be used for ceiling mounted ring ground instead of copper wire. Ground copper bus bar 2” x ¼” shall be provided around the inside perimeter of the substation building, both at the top and at the bottom of the building.

2.02 CONSTRUCTION

A. All structural steel shall be hot-dipped galvanized as required by the Contract Documents.

B. The base shall be fabricated from hot-dip galvanized structural steel channel, rigidly braced with steel cross members to provide adequate strength for lifting the complete assembly including all equipment. Touch up welds with a brush coat of zinc rich paint.

C. The inside floor shall consist of ¼ inch minimum galvanized steel plate welded to the base, with cutouts for conduit entry as required. The floor shall withstand the weight of the heaviest circuit breaker, transformer or other equipment item which may have to be moved along the floor, without significant deflection. Design the base to permit natural ventilation between substation enclosure and concrete foundation to prevent condensation and buildup of water.

D. Exterior walls and roof shall be constructed from 12 gauge hot-dipped galvanized or galvanealed steel. Interior walls shall be constructed from 14 gauge hot-dipped galvanized or galvanealed steel.

E. The roof shall be shed type as shown on the Contract Drawings. The roofing shall be interlocking metal, with rain caps over roof seams sealed to prevent water entry. A rain test shall be conducted as indicated in Section 34 21 63 3.3.D. Building roof and leak shall have an extended warranty of 5 years.

F. Access to the substation equipment shall be from the sides and the rear. The construction of the building shall allow the removal of all major equipment from the substation building without disassembly of the equipment.

G. Provide painted aluminum rain gutters and down spouts.

2.03 THERMAL AND AUDIBLE NOISE INSULATION

A. The roof, exterior walls and doors shall be insulated and the construction method shall be approved by VTA resulting in an overall "U" factor of 0.27. Exterior wall panels shall be weatherproof with interlocking seams.

B. Minimize transformer noise level by the winding and core design and by the resilient mounting of the core and coil of the transformer.

C. The external audible noise level shall be 60 dB (A) maximum at any point three feet away from the enclosure with the transformer-rectifier unit energized at rated input voltage and at 150 percent full load current.

D. The interior audible noise level shall not exceed 70 dB (A) inside the substation enclosure at any location three feet away from the equipment, with the rectifier transformer unit energized at rated input voltage and 150 per cent full load current.

E. Limit ventilation equipment noise to 55 dB (A) at any location three feet from the building exterior.

2.04 PERSONNEL DOORS

A. Personnel doors shall be insulated and fabricated from 14 gauge galvanized or galvanealed steel.

B. Equip the personnel doors with “crash bar” panic hardware, stainless steel hinges with stainless steel hinge pins, and a door holder to maintain the door in the open position.

C. Provide a flush-mounted, hardened, vandal-resistant, key-lock cylinder with a dust cover on the outside of the door. Information of the lock-set type will be provided by VTA.

D. Provide a panic bar on the inside of the door to allow fast exit even though the doors are locked.

E. Provide heavy-duty intrusion alarm monitoring devices for the doors. Wire the devices to the Communication Interface Cabinet.

F. Doors shall be tightly sealed with neoprene gaskets. Secure seals to the doors to allow easy replacement.

G. Design of doors shall prevent intrusion of water around the seams under maximum ventilation pressure.

2.05 EXTERIOR EQUIPMENT DOORS

A. Fabricate equipment doors from 11 gauge galvanized or galvanealed steel.

B. Latches shall be three-point, pad-lockable, heavy duty stainless steel switchgear type. Hinges, hinge pins and hardware shall be stainless steel. Provide a minimum of three concealed hinges.

C. Provide one heavy duty padlock keyed per VTA requirements for each external door.

D. Provide hinged equipment access doors to allow access to the rear of the ac switchgear, rectifier, transformer, and dc switchgear from the outside of the substation for regular maintenance. Clear polycarbonate or lexan shall be provided to prevent accidental contact with live high-voltage components when they are exposed. Perforated lexan is required where ventilation is needed.

E. Doors shall be rated NEMA 4, gasketed and intended to provide protection from windblown dust and rain, splashing and hose directed water. The doors shall provide protection from the insertion of foreign objects such as sticks.

F. Door gaskets shall be neoprene. Secure seals to the doors to allow easy replacement.

G. Doors 36 inches or wider shall include vertical stiffeners. Provide a minimum of three stiffeners for a 36-inch door, with one additional stiffener for each additional 12 inches of door width. Doors shall meet or exceed the requirements of NEMA SG5 and NEMA ICS-6 for weatherproofing.

H. Provide each access door with the same flush-mounted key-lock cylinder with dust cover as the entry doors, using a different key.

I. Provide intrusion alarm monitoring devices for the doors.

2.06 HEATING AND VENTILATION

A. Provide continuous exhaust ventilation and backdraft dampers to vent heat, toxic, flammable or harmful gases to the outside.

B. Design the ventilation for the most efficient and effective cooling of the transformer rectifier unit and switchgear buses. Use actual full load losses from manufacturers approved shop drawings for the transformer and rectifier when preparing calculations.

C. Design the ventilation for the following parameters

1. Interior temperature shall not rise above 104°F when interior temperature reaches 90°F under full load conditions. Use actual equipment full load losses for calculation.

2. Heating shall be sufficient to maintain the substation at 70°F inside when the outside ambient air temperature falls to 20°F.

D. HVAC units shall be provided and shall be wall or ceiling mounted and rated for 10 kW minimum and controlled from remote wall mounted thermostats.

E. Fan motors shall be single phase, open drip proof, across the line starting, with a service factor of 1.15.

F. The noise level of the fan-motors shall not exceed 55 dBA at 3 feet.

G. Do not mount fans over or immediately adjacent to equipment. Provide baffles, louvers and other means as required, to protect against splash, driving rain and infiltration of dust or foreign objects. Size louvers per calculations.

H. Filters shall be readily accessible, removable and replaceable. Exterior openings shall be baffled and hooded to prevent the entry of foreign objects or moisture into the substation building under maximum ventilation pressure. Provide one additional set of filters for each TPSS at the time of acceptance.

I. Fan control shall be two stage, with automatic or manual operation from the motor starter and wall mounted thermostat. Ventilation fans shall have digital thermostats with settings adjustable from 55°F to 90°F. Fans shall have a manual thermostat bypass switch located by the entrance door. The bypass shall incorporate a timer such that the bypass returns to normal after two hours to allow the fans to operate under their normal thermostatic control.

J. All vents shall be insect and vermin proof and protected to prevent foreign objects entering TPSS.

2.07 SUBSTATION LIGHTING

A. A lighting layout shall be submitted with the building design drawings. Interior lighting layout shall be designed to adequately light all panels, labels, meters, and switch handles. Exterior lighting shall illuminate all entry doors.

B. Lights shall be powered from the substation auxiliary power supply.

C. Interior lighting shall be industrial quality, self-contained fluorescent to provide a minimum of 50 foot candles horizontal at 30 inches above the aisle floor. Control the interior lighting by switches near each entry door.

D. Interior Lighting

1. Type: Ceiling mounted, linear LED luminaire

2. Lens: Wrap around polycarbonate or high-impact acrylic diffuser, UV resistant, with even light distribution, secured to the housing with fasteners.

3. Standards: Complying with UL 8750.

4. Correlated Color Temperature (CCT): 5000-6000 K

5. LED Driver: Field replaceable

6. MTBF: Minimum 50,000 Hours

7. Lighting at doorways and required in emergencies shall be emergency lights as described below in 2.7.G.

E. Exterior Lighting

1. General:

   a. Wall-mounted, vandal-resistant, LED luminaire, full cut-off type.

   b. UL listed for 40 degrees C maximum ambient and wet locations with IP66 ingress rating. Luminair eshall comply with IES LM-79 and LM-80 and be DLC (Design Lights Consortium) qualified.

2. Housing:

   a. Die-cast aluminum, with a hinged door secured by captive stainless steel, tamper-resistant screw.

   b. Housing shall incorporate cooling fins specifically designed for cooling

LED light source and driver.

c. Approximate dimensions of complete luminaire: 6"W x 7"H x 4"D including back-box provided with wire guard.

3. Finish: Epoxy or polyester powder-coat paint, white, or as directed by Engineer.

4. Optical:

a. Sealed LED compartment with anodized, mirror-finish, forward-throw reflector, high-output bright-white (5000 CCT) LED, impact resistant tempered glass lens and silicone sealing gaskets.

b. Luminaire shall deliver at least 1400 lumens, be rated full-cutoff with BUG rating B1-U0-G0 or better, and be suitable for wall-mounting 8 feet or greater above surrounding surface.

5. Electrical

a. Integrated electronic LED driver with integral surge protection shall be mounted to housing for effective cooling.

b. Provide luminaries with integral photocontrol or a single NEMA-style, amiable photocontrol wired in luminaire circuit.

F. Photoelectric Control

1. Photoelectric controls shall be a NEMA-type, twist-lock, plug-in device rated at 1800 VA and 120 volts. Operating level shall be: Turn-On Average: 1.0, plus or minus 0.2 footcandles; Turn-On Maximum: 1.8 footcandles; Turn-Off Ratio: 3.0 footcandle average. Acceptable controls are Fisher Pierce 6660 or 6690-B series, or approved equal.

G. Emergency Lighting

1. The average emergency lighting intensity to be at least five foot-candles horizontal at 30 inches above the aisle floor. Illuminate the emergency lights only on loss of ac power and only when the entry door double pole switches are activated by personnel.

2. Emergency lighting assemblies shall comply with UL 924 and shall be self-contained units, with battery and charger, suitable for 120 Vac power supply.

3. Battery shall be sealed, maintenance-free, lead-calcium type, suitable for float service with 15 year life expectancy and 5-year extended warranty. Battery shall have 1-1/2 hour minimum cut off capacity from fully charged state.

4. Battery charger shall be solid state, current limited, temperature compensated, short-circuit proof, reverse polarity protected, with plus or minus 1% regulation. Charger shall automatically maintain battery in fully charged float condition and shall be capable of providing full recharge.

5. Assembly shall be provided with the following accessories:

    a. Operating test switch, with spring return

    b. Ac supply healthy pilot lamp

    c. High-charge supervision lamp

    d. Battery low-voltage load cut-off protection

    e. Automatic connection of lamp load through a wall switch upon failure of ac supply and automatic disconnection following restoration of ac supply

2.08 EMERGENCY POWER

A. Provide a 100A, 250V, power receptacle designated for use with an emergency generator.

B. Install the emergency power receptacle on the exterior wall of the substation enclosure.

C. The emergency power receptacle shall be furnished with the following:

    1. NEMA 4X waterproof enclosure
    2. Lid
    3. 30° angle hood
    4. Integral lockout
    5. Safety shutter

D. Provide a 150A, 250V double-pole, double-throw (DPDT) transfer switch to isolate the emergency generator from the utility power.

E. The status of the transfer switch shall be transmitted to the annunciator and SCADA.

2.09 POWER RECEPTACLES

Provide duplex, heavy-duty, 20 ampere, 120 Vac, 3-wire, GFCI-type receptacles, conforming to NEMA PR4.

2.10 FIRE EXTINGUISHERS

A. All Traction Power Substations shall be equipped with two Carbon dioxide (CO_2) fire extinguishers, intended for Class B and Class C fire hazards.

B. Fire extinguishers shall be portable wall-mount type and shall be UL rated 10B:C.

C. CO_2 containers shall be heavy-duty, seamless, aluminum alloy cylinders, painted red, with instruction labels permanently affixed.

D. Discharge mechanism shall have a locking pin to prevent accidental discharge.

E. Fire extinguisher shall have a flexible hose and horn for aiming at the fire.

F. Fire extinguisher shall meet or exceed the following specifications:

1. CO_2 Capacity 15 lbs
2. Weight 20 lbs maximum
3. Range 50 feet

2.11 EMERGENCY TRIP SYSTEM

A. Provide an Emergency Trip System (ETS) to disconnect all power to and from the TPSS under emergency conditions. Provide a Control System as described herein.

1. Provide two interior emergency trip devices and one exterior emergency trip device for each TPSS.
2. Provide one interior device at each access door where shown on the Contract Drawings. The indoor device shall be a "mushroom" shaped large pushbutton switch, with a protective cover. Clearly label the device "EMERGENCY TRIP" and protect it from accidental trip. The ETS device shall be a lockout type requiring manual reset.
3. The outdoor disconnect device shall be recessed mounted in a lockable type "Knox Box", with dual entry locks made of stainless steel.
4. The exterior lock system shall be keyed to the appropriate keying system for the local jurisdictional Fire Department and VTA maintenance. The Contractor shall contact the VTA for the proper forms and procedures prior to purchasing the "Knox Box" or keying. Keys shall be furnished for each exterior switch.
5. Each emergency trip device shall be equipped with a heavy duty, industrial

grade, pushbutton operator and contact blocks, with a large, red, mushroom shaped actuating head.

6. Design the pushbuttons so that if a substation has been taken “off-line” by the Emergency Trip Scheme, it cannot be re-energized locally or remotely unless the ETS has been manually reset.

7. Outdoor boxes shall be of stainless steel, locking and keying of the outdoor boxes must be coordinated and approved by VTA.

2.12 INTRUSION DETECTION

Intrusion Detection Sensor

1. Each TPSS entry door and each exterior equipment access door shall be equipped with a magnetic switch to detect when the door is opened.

2. After the door is opened, there shall be a delay (30 seconds) before an alarm is signaled. During this delay, the alarm can be deactivated from a keypad by entering a preset valid four-digit security code.

3. If an intrusion is detected by the local control panel and not deactivated by the local keyboard, the system shall activate a local alarm bell and shall send an alarm to the Operations Control Center (OCC) via SCADA.

2.13 FIRE DETECTION

A. Fire detection at the TPSS shall be accomplished utilizing a smoke/heat detector alarm contact to operate the lockout trip relay as shown in the single line diagram.

B. Provide smoke/heat detectors at strategic locations to detect smoke or products of combustion. The operation of the circuit breakers shall not activate the smoke/heat detection system.

C. Smoke/heat detectors shall be of ionization photo electric type and designed to reduce false alarms from dust, insects, RFI, and external light.

2.14 MISCELLANEOUS EQUIPMENT

A. Furnish miscellaneous equipment as indicated in the Contract Documents or specified herein including hinged work bench and plan holder. Work bench shall be a folding type with 1-1/2 inches solid wood top at least 30 inches by 72 inches, with heavy-duty hinges and chains and shall be approved by VTA.

B. Furnish a metal tool box 24: wide x 60” high x 18” deep with shelving to store special tools, equipment and spare parts.

2.15 PAINTING

Clean, prime, and paint the substation enclosures as follows:

4. All steel surfaces to be painted shall be cleaned and otherwise prepared for painting by a three-step process consisting of an alkaline wash, phosphatizing and an acid wash, or other equal process recommended by the paint manufacturer and approved by VTA.

5. Exterior steel shall be mill-galvanized before finishing.

6. Apply one coat of rust-inhibitive primer and two coats of lacker or enamel to all surfaces.

7. Coat under surfaces of the outdoor enclosure base, with a thick, airtight coat of heavy sealing material to provide lasting protection of the under surfaces from deterioration.

8. Protect all surfaces on the exterior walls and roof with two factory-applied coats of a non-sacrificial, anti-graffiti type of protective coating applied after the finish paint. The finish paint and protective coating shall be compatible. Protective coating shall be a two-component aliphatic polyurethane solvent based coating system, Tamms Industries' Aquathane or equal. Mask hardware, such as locks, light fixtures, and hinges, during applications of the protective coating.

9. Finish interior wall and ceiling color shall be high-gloss white. Exterior color shall closely match that of the existing VTA substations, which is a shade of beige. Provide for future touch-up with one gallon each of the approved exterior and interior paints with each substation delivered.

10. Coat undersurfaces of the substation enclosure with a thick, air-tight coat of heavy sealing material to protect against deterioration.

2.16 LIFTING LUGS

A. Provide removable lifting lugs that are securely bolted to the enclosure suitable for safely lifting and placing the enclosure on its foundation without any structural, mechanical or electrical damage to it or the equipment mounted inside. Lifting lugs shall be designed to prevent damage to exterior paint surfaces.

B. Contractor shall furnish one complete set of lifting lugs to VTA. The lugs shall be constructed such that they will fit on any housing furnished under this Contract.

2.17 INTRUSION PREVENTION

All building penetrations such as ventilation intakes or outlets shall be designed to prevent intrusion of animals or vermin and shall prevent penetration by foreign objects from contacting energized electrical busses or equipment.

2.18 STEPS AND RAILINGS

Provide steps, ladders and railings in accordance with the Contract Documents.

2.19 ISOLATION TRANSFORMER – not used

2.20 ELECTRICALLY INSULATED FLOOR COVERING

The electrically insulated floor covering shall cover the entire floor with an epoxy material, consisting of two semi-fluid components which contain no Portland cement. When blended together and mixed with the proper proportion of suitable aggregate, the epoxy shall harden into a solid mass. The epoxy material shall be an approved color, and shall be installed according to the manufacturer's specification. It shall be suitable for application to a thickness of ¼ inch or greater, minimum. It shall harden in approximately 8 hours and shall be ready for full service by the next day. It shall be resistant to fire and acids, resist abrasion and impact, and shall be suitable for industrial trucking where heavy loads are involved. The epoxy flooring shall be dense, resist thermal expansion and contraction, skid proof, dustless, and shall have a high electrical insulation resistance. The flooring shall not be affected by high or low ambient temperatures after cure. The epoxy coating shall meet the following requirements:

11. Minimum Cure Thickness: ¼ inch
12. Compressive Strength: ASTM C-579, 9800 psi after seven days
13. Flexural Strength: ASTM C-589, 2080 psi after seven days
14. Shore "D" Hardness: 65 after 24 hours, 75 after seven days
15. Impact Strength
    a. ASTM D2794
    b. Gardner tube falling cylinder
    c. 80 in-lbs
    d. Higher than tensile strength of good quality concrete (400 psi)
16. Water Absorption: ASTM C413 seven days at 77 degrees F, 0.03 percent
17. Electrical Strength: 50 kV, minimum
18. Color: As approved by VTA

19. Acceptable Manufacturer: Epoxylight or approved equal

Floor shall be tested in accordance with section 34 21 63, Testing and Commissioning.

2.21 ELECTRICAL INSULATING LAMINATES

A. "Electrical insulating laminates" or "laminates" that are called out in the Drawings or Specifications for areas other than the floors shall conform to the following requirements:

1. Mechanical Properties
    a. NEMA Grade – GPO-2, GPO-2P
    b. Tensile Strength (psi) 8,900
    c. Flex Strength (psi) 24,000
    d. Shear Strength (psi) 13,000
    e. Water Absorption percentage by wt 0.6
    f. Specific Gravity 1.97
2. Electrical Properties
    a. Electric Strength – 443 V/M Perpendicular in air Arc Resistance, 130 Sec
    b. Permitivity, 60 Hz (per ASTM D150) – 4.1
    c. Insulation Resistance 270 X 1012 Ohms
3. Flame Resistance
    a. UL Subject 94 – VO
    b. UL Hot Wire Ignition 300 sec
    c. UL High Amp Ignition 200 exposure
    d. Ignition time 81 min
    e. Burn Time 48 sec
4. Compliances

5. UL 94V-O

B. The electrical insulating laminate shall be an electrical grade fiberglass-reinforced polyester sheet, as manufactured by Glastic, UTS grade, red color, part number 1478, or approved equal.

C. All cut surfaces shall be sealed with epoxy.

PART 3 - EXECUTION

3.01 INSTALLATION

Install the substation buildings on the building foundations in accordance with Section 34 21 53 – Traction Power Substation Field Installation.

3.02 INTEGRATED TESTING

A. The Contractor shall support integrated testing of the following systems installed for the new traction power substations under this Contract:

1. Emergency Trip System
2. Intrusion Detection System
3. Fire Alarm System
4. The testing shall include end-to-end tests to verify that field equipment transmits proper indications and alarms to the OCC and performs properly upon receipt of SCADA commands. VTA will provide operations and test personal in the OCC to support the testing including monitoring of OCC SCADA equipment and initiation of SCADA commands.

END OF SECTION 34 21 16

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SECTION 34 21 17

HMI AND SCADA INTERFACE REQUIREMENTS

PART 1 - GENERAL

1.01 SUMMARY

This Section specifies the requirements of the HMI and interfacing between the Traction Power Substations and the existing Supervisory Control and Data Acquisition (SCADA) system.

The main human machine interface (HMI) panel shall be flush mounted on the front door of the communication interface cabinet. Individual display/HMI for each multi-function microprocessor protective device shall be installed flush on its associated equipment control cabinet door.

1.02 REFERENCE STANDARDS

A. Referenced standards and codes, whether or not cited in this Section, are minimum requirements. The interpretation or the applicability of the referenced standards for products specified in this Section shall be decided by VTA, whose decision shall be final.

1.03 SUBMITTALS

A. Refer to Section 01 33 00 – Submittals.

B. Submit the following for approval within 30 calendar days after Notice to Proceed:

1. Equipment layouts and physical dimensions for the HMI panel consisting of:

    a. Plan

    b. Elevation

    c. Sections

2. Submit Product Data on the following items:
    a. Instructions for initial set up configurations, programming, and communication of the devices with the SCADA system.
    b. For each component of PAC equipment:
        i. Functional block diagram
        ii. Wiring and interconnection drawings
        iii. Bill of material listing of all installed components

iv. Power cabling, data communications cabling and I/O wiring diagrams

c. Product application software, firmware, initial set up configurations

1.04 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed thereafter.

1.05 QUALITY CONTROL

Refer to General Conditions GC-47, Quality Assurance, for general requirements and procedures.

PART 2 - PRODUCTS

2.01 HUMAN MACHINE INTERFACE (HMI) PANEL

A. General: The human machine interface (HMI) panel shall be complete, with an industrial touch screen monitor and all auxiliary devices necessary, and be compatible with the PAC for the controlling and monitoring substation events and alarms as indicated in the Contract Documents.

B. The HMI panel shall be minimum 19” high brightness TFT LCD touch- screen, with speakers to visually annunciate equipment status and alarms and audibly annunciate alarms. The panel shall be flush mounted on the front upper compartment door of the communication interface cabinet.

C. The HMI panel shall have the following features:

1. Flash/RAM storage memory with at least 12288 Kbyte

2. Resolution 1920 x 1080 pixels or better

3. At least 50,000 h for MTBF backlighting at 25 degree C

4. Touchscreen, analog, resistive

5. Degree of protection: Front, IP 65/NEMA 4; rear, IP 20

6. Acoustics: sound signal WAV tone

7. Interfaces: 1 x RS 422; 1 x RS 485; 1 x CF card slot; 1 x multi-media card slot;

2 x USB; 2 x Ethernet (RJ45)

8. Input: VGA, DVI, HDMI

9. Size: minimum 22 inches diagonal

10. Anti-glare and anti-reflective display

D. Power Supply

1. A dedicated power supply shall be provided for the HMI panel. The power supply shall operate with the substation 125 Vdc supply. Provide a white indicator light to indicate the availability of 125 Vdc supply.

2. The power supply shall be supervised by a voltage detector, which shall initiate SCADA annunciation upon loss of supply.

E. Spare Capacity: HMI panel shall be adequately sized and equipped to accommodate additional points for future needs.

F. Operations

1. The HMI shall provide screens for:
   - Substation single line including device status
   - Substation events, alarms and status indications
   - Substation equipment controls
   - Substation device communications
   - Mimic of the substation annunciator

2.02 SCADA INTERFACE REQUIREMENTS

A. The substation SCADA system interfaces with the Operation Control Center (OCC) via the existing network.

B. The interface between the SCADA system and the substation control, alarm, and status indications shall be implemented by the substation Programmable Automation Controller (PAC).

C. The substation SCADA interface system, which resides at the communication interface cabinet, shall consist of the following:

1. PAC

2. Digital and analog I/O cards

3. Power supplies

4. Communication equipment, including Ethernet switches and media converters.

5. Network cabling

6. Equipment cabinet

7. Miscellaneous equipment

D. SCADA PAC: Refer to Section 34 21 71 – SCADA Programmable Automation Controller

E. Substation PAC: Refer to Section 34 21 18 – Substation Microprocessor Controlled Devices and Intelligent Electronic Devices

F. Digital Input/Output (I/O) and Analog I/O Cards shall have the following features:

1. Digital input shall be from substation dry contacts wetted by SCADA power.

2. Digital Output cards will have isolation relays with relay contacts wetted by substation power.

3. Analog input cards shall accept analog current or voltage input signals compatible with the signals transmitted from field devices and instruments.

4. Analog output cards shall provide analog current or voltage output signals compatible with the signals required to control the field devices.

5. Current and voltage ratings shall be compatible with substation equipment ratings.

6. Power supplies shall be redundant. Any one supply shall be able to power the SCADA equipment with a margin of 50%. All power supplies shall be backed up by a UPS.

G. Communication Link and Wiring

1. An Ethernet link shall be established in the substations for communication to the OCC.

2. Cabling shall be provided. Cabling shall include power cable, digital I/O cables, analog cabling, ground cable, CAT-6 and other communication cable. Fiber optic cable may be used dependent upon the final design. Cabling sizing and ratingshall depend upon the final design.

3. Terminal blocks and compatible interface modules shall be used for interconnecting equipment. Terminal blocks will allow disconnecting for testing and trouble- shooting. SCADA and substation equipment can be separately tested and verified before interconnection.

4. Miscellaneous items shall include cabinets, ground bars, mechanical fasteners, and other items.

H. All the switchgear controls, indications, and alarms shall be wired to the I/O cards associated with the substation PAC, which include at least:

1. Open and closed status of breakers

2. Local/remote control status of breakers

3. Alarm points as indicated at the substation annunciator

4. 50 percent spares shall be provided for the terminals of I/O cards associated with both the substation and SCADA PACs.

2.03 SCADA POINTS

A. SCADA points are listed in Tables 34 21 71A below.

B. Control of circuit breakers from the OCC via the SCADA system shall be as follows:

1. Tripping by remote command only when the REMOTE OFF/ON switch is in the ON (remote) position.

2. Closing by remote command only when the REMOTE OFF/ON switch is in the ON (remote) position.

PART 3 - EXECUTION

3.01 INTEGRATED TESTING

The Contractor shall support integrated testing of the annunciator and SCADA points for the new traction power substations installed under this Contract. The testing shall include end-to-end tests to verify that field equipment transmits proper indications and alarms to the OCC and performs properly upon receipt of SCADA commands. VTA will provide operations and test personnel in OCC to support the testing including monitoring of OCC SCADA equipment and initiation of SCADA commands.

TABLE 34 21 17A
TYPICAL I/O POINTS FOR NEW TPSS #33 and #34

Point Description	Pt. Type	SCADA	HMI (Annunciator)
UTILITY			
Utility Supply Overvoltage Trip	DI, S	X	X
Utility Supply Undervoltage Trip	DI, S	X	X
OCS SYSTEM			
TPSS # 33			
OCS Sect NBXXXX – Line Side - De-energized (Refer to contract drawings for section references)	DI, H	X	X
OCS Sect SBXXXX – Line Side - De-energized (Refer to contract drawings for section references)	DI, H	X	X
OCS Sect NBXXXX – Line Side - De-energized (Refer to contract drawings for section references)	DI, H	X	X
OCS Sect SBXXXX – Line Side - De-energized (Refer to contract drawings for section references)	DI, H	X	X
OCS Sect NBXXXX – Load Side - De-energized (Refer to contract drawings for section references)	DI, H	X	X
OCS Sect SBXXXX – Load Side - De-energized (Refer to contract drawings for section references)	DI, H	X	X
OCS Sect NBXXXX – Load Side - De-energized (Refer to contract drawings for section references)	DI, H	X	X
OCS Sect SBXXXX – Load Side - De-energized (Refer to contract drawings for section references)	DI, H	X	X

Abbreviations:

DI = Digital Input
H = Hard-Wired
DO=Digital Output
AO=Analog Output
S = Soft Bit

TABLE 34 21 17A
TYPICAL I/O POINTS FOR NEW TPSS #33 and #34 (Cont.)

Point Description	Pt. Type	SCADA	HMI (Annunciator)
TPSS # 34			
OCS Sect NBXXXX – Line Side - De-energized (Refer to contract drawings for section references)	DI, H	X	X
OCS Sect SBXXXX – Line Side - De-energized (Refer to contract drawings for section references)	DI, H	X	X
OCS Sect NBXXXX – Line Side - De-energized (Refer to contract drawings for section references)	DI, H	X	X
OCS Sect SBXXXX – Line Side - De-energized (Refer to contract drawings for section references)	DI, H	X	X
OCS Sect NBXXXX – Load Side - De-energized (Refer to contract drawings for section references)	DI, H	X	X
OCS Sect SBXXXX – Load Side - De-energized (Refer to contract drawings for section references)	DI, H	X	X
OCS Sect NBXXXX – Load Side - De-energized (Refer to contract drawings for section references)	DI, H	X	X
OCS Sect SBXXXX – Load Side - De-energized (Refer to contract drawings for section references)	DI, H	X	X
OCS Sect NBXXXXA – Load Side - De-energized (Refer to contract drawings for section references)	DI, H	X	X
OCS Sect SBXXXXA – Load Side - De-energized (Refer to contract drawings for section references)	DI, H	X	X
AC SWITCHGEAR			
AC Breaker Open	DI, S	X	
AC Breaker Trip	DI, S		X
AC Breaker Closed	DI, S	X	

TABLE 34 21 17A TYPICAL I/O POINTS FOR NEW TPSS #33 and #34 (Cont.)			
Point Description	**Pt. Type**	**SCADA**	**HMI (Annunciator)**
AC Overcurrent Trip (50/51)	DI, S	X	X
AC Overcurrent Trip (50N/51N))	DI, S	X	X
Loss of Control Power (AC Switchgear)	DI, H	X	X
Lockout Relay 86-1	DI, H	X	X
AC Overcurrent Relay Fail	DI, S	X	
Loss of Station Services Power (27S)	DI, H	X	X
AC Switchgear Door Open	DI, H	X	X
Open AC Breaker	DO, S	X	
Close AC Breaker	DO, S	X	
AC Breaker Multifunction Protection Relay Failure	DI, S	X	X
TRANSFORMER / RECTIFIER			
Rectifier Second Diode Failed Trip	DI, H	X	X
Rectifier First Diode Failed Alarm	DI, H	X	X
Rectifier Overtemp Trip	DI, H	X	X
Rectifier Overtemp Alarm	DI, H	X	X
Rectifier Surge Protection Failed	DI, H	X	X
Transformer Overtemp Trip	DI, H	X	X
Transformer Overtemp Alarm	DI, H	X	X
Transformer/Rectifier Door Open	DI, H	X	X
Loss of Control Power Transformer/Rectifier	DI, H	X	
DC SWITCHGEAR			
DC Feeder Breaker F1 Open	DI, S	X	
DC Feeder Breaker F1 Trip	DI, S	X	X
DC Feeder Breaker F1 Closed	DI, S	X	
DC Feeder Breaker F1, DC Protective Unit & Controller Failure	DI, S	X	X
DC Feeder Breaker F2 Open	DI, S	X	
DC Feeder Breaker F2 Trip	DI, S	X	X
DC Feeder Breaker F2 Closed	DI, S	X	
DC Feeder Breaker F2, DC Protective Unit & Controller Failure	DI, S	X	X
DC Feeder Breaker F3 Open	DI, S	X	
DC Feeder Breaker F3 Trip	DI, S	X	X
DC Feeder Breaker F3 Closed	DI, S	X	
DC Feeder Breaker F3, DC Protective Unit & Controller Failure	DI, S	X	X
DC Feeder Breaker F4 Open	DI, S	X	
DC Feeder Breaker F4 Trip	DI, S	X	X
DC Feeder Breaker F4 Closed	DI, S	X	
DC Feeder Breaker F4, DC Protective Unit & Controller Failure	DI, S	X	X

TABLE 34 21 17A
TYPICAL I/O POINTS FOR NEW TPSS #33 and #34 (Cont.)

Point Description	Pt. Type	SCADA	HMI (Annunciator)
Transfer Trip Failure F1	DI, H	X	X
Transfer Trip Failure F2	DI, H	X	X
Transfer Trip Failure F3	DI, H	X	X
Transfer Trip Failure F4	DI, H	X	X
Transfer Trip Disabled F1	DI, H	X	X
Transfer Trip Disabled F2	DI, H	X	X
Transfer Trip Disabled F3	DI, H	X	X
Transfer Trip Disabled F4	DI, H	X	X
Recloser Lockout F1	DI, S	X	X
Recloser Lockout F2	DI, S	X	X
Recloser Lockout F3	DI, S	X	X
Recloser Lockout F4	DI, S	X	X
DC Main Breaker Open	DI, S	X	
DC Main Breaker Trip	DI, S	X	X
DC Main Breaker Closed	DI, S	X	
DC Main Breaker Reverse Current Trip (32)	DI, S	X	X
Negative Disconnect Switch Open	DI, H	X	X
Lockout Relay 86-2	DI, H	X	X
DC Switchgear Enclosure Alive Trip	DI, H	X	X
DC Switchgear Enclosure Grounded Alarm	DI, H	X	X
DC Rectifier Enclosure Alive Trip	DI, H	X	X
DC Rectifier Enclosure Grounded Alarm	DI, H	X	X

TABLE 34 21 17A TYPICAL I/O POINTS FOR NEW TPSS #33 and #34 (Cont.)			
Point Description	**Pt. Type**	**SCADA**	**HMI (Annunciator)**
DC Negative Grounding Unit Failure	DI, H	X	X
DC Negative Grounding Overcurrent Operation	DI, H	X	X
Substation Transfer Trip By-Passed	DI, H	X	
Loss of Control Power DC Switchgear	DI, H	X	X
DC Breaker/Negative Disc. Switch Door Open	DI, H	X	X
Close DC Feeder Breaker F1	DO, S	X	
Open DC Feeder Breaker F1	DO, S	X	
Close DC Feeder Breaker F2	DO, S	X	
Open DC Feeder Breaker F2	DO, S	X	
Close DC Feeder Breaker F3	DO, S	X	
Open DC Feeder Breaker F3	DO, S	X	
Close DC Feeder Breaker F4	DO, S	X	
Open DC Feeder Breaker F4	DO, S	X	
Close DC Main Breaker	DO, S	X	
Open DC Main Breaker	DO, S	X	
MISCELLANEOUS ITEMS			
Fire Alarm	DI, H	X	X
Fire Equipment Failure	DI, H	X	
125V DC System Ground Fault Alarm	DI, H	X	X
Battery Undervoltage Alarm	DI, H	X	X
Battery Undervoltage Trip	DI, H	X	
Battery Charger Failure (27A)	DI, H	X	X
Annunciator/HMI Power Failure	DI, H	X	
AC Aux. Power Alternate Supply	DI, H	X	X
Substation Temperature High	DI, H	X	X
Intrusion Alarm	DI, H	X	X
AC Panelboard Breaker trip (individual breaker)	DI, H	X	X
DC Panelboard Breaker trip (individual breaker)	DI, H	X	X
Emergency shutdown	DI, H	X	X
Local Control for the whole Substation (AC, DC, F1 – F6 Breakers)	DI, H	X	X

END OF SECTION 34 21 17

SECTION 34 21 18

SUBSTATION MICROPROCESSOR CONTROLLED DEVICES AND INTELLIGENT ELECTRONIC DEVICES (IEDs)

PART 1 - GENERAL

1.01 SUMMARY

This Section covers the requirements for the application of microprocessor-controlled devices and intelligent electronic devices (IEDs) for the traction power substation. The IEDs shall interface with the SCADA system PAC per specification 34 21 71.

1.02 REFERENCE STANDARDS

A. Pertinent provisions of the latest edition of the following listed standards shall apply to the Work of this Section, except as they may be modified herein, and are made a part of this Specification to the extent required.

B.

Organization	Number	Title
ASCII	General	American National Standard Code
ANSI	C37.1	Standard Definition, Specification, and Analysis of Systems used for Supervisory Control Data Acquisition and Automatic Control
ANSI	C.37.90.1	Standard Surge Withstand Capability (SWG) Tests for Protective Relays and Relay Systems
ANSI	C.37.90.2	Standard Withstand Capability of Relay Systems to radiated Electromagnetic Interference From Transceivers
ANSI/IEEE	730	Software Quality Assurance Plans
ANSI	X3.15	Bit Sequencing for Information Interchange in Serial-By-Bit Data Transmission
EIA	RS-232C	Physical Interface Between Data Terminal Equipment and Data Communication Equipment

EIA	RS-422	Electrical Characteristics of Balance Voltage Digital Circuit
EIA	RS-485	Standard for Data Communication Equipment
IEC	61131-2	Programmable Controllers – Part 2: Equipment Requirements and Tests
IEEE	281	Standard Service Conditions for Power System Communication Equipment
IEEE	802.1	Standard for Overall Architecture of Local Area Network and Internet-Working
IEEE	802.5	Standard for Local Area Networks: Token Ring Access Method and Physical Layer Specifications
IEEE	802.8	Standard on Fiber-Optic LANS
IEEE	C37.90.1	IEEE Standard for Surge Withstand Capabilities (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
NEMA	ICS6	Enclosures for Industrial Controls

1.03 SUBMITTALS

A. Refer to Section 01 33 00 – Submittals.

B. Submit the following with shop drawings, product data and samples for approval within 120 calendar days after Notice to Proceed:

1. Complete manufacturers catalog data of each device
2. Documentation to establish service proven history for both hardware and software
3. Complete ladder logic control schematic shop drawings with contacts and devices properly labeled for all IEDs
4. Complete wiring and interconnection diagrams
5. Complete source code for IEDs
6. Complete and latest electronic version of application software and

documentation for user programming, Windows based with a version compatible with all software and hardware

7. Operation and Maintenance Manuals and Troubleshooting Guide

8. Reliability Data including Mean Time Between Failures

1.04 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed thereafter.

1.05 QUALITY CONTROL

Refer to General Conditions GC-47, Quality Assurance Program, for general requirements and procedures.

1.06 QUALITY ASSURANCE

Microprocessor-controlled devices and IEDs shall be UL labeled or NETA certified from a third party testing laboratory recognized by the State of California.

1.07 APPLICATION

A. Fast-acting microprocessor-controlled device shall be used for one or more of the following functions associated with each individual dc circuit breaker.

1. Load measuring
2. Reclosing and lockout
3. Transfer trip sending and receiving
4. Thermal overload
5. Reverse current
6. Rate of rise

B. Fast-acting microprocessor-controlled device might be used for one or more of the following functions associated with the negative grounding unit:

1. Negative grounding overvoltage

2. Instantaneous current

3. Short delay timer

C. The following functions must be controlled by individual protective relays or devices and shall not be microprocessor or IED controlled:

1. Ac lockout relay

2. Low resistance frame fault relay

3. Dc feeder direct-acting trip device

4. Dc lockout relay

D. All necessary hardware, software, and diagnostics equipment to ensure a fully operational and coordinated system shall be included.

E. Microprocessor-controlled devices or IEDs shall be programmed specifically for Traction Power Substation application.

F. Microprocessor-controlled devices or IEDs shall meet all requirements called out elsewhere in this specification for the ANSI device or devices they are replacing.

1.08 GENERAL DESIGN REQUIREMENTS

A. Microprocessor-controlled devices or IEDs shall be of a proven design in accordance with the following criteria:

1. Have at least 15 identical units in operation in a similar application in railroad or rail transit service for a minimum of three years or as approved by VTA.

2. Have demonstrated high reliability.

B. Software shall either be of a proven design in accordance with the criteria specified above or shall meet the requirements of this specification for development of new software.

C. To demonstrate a service proven design, details of the application history shall be submitted, including number of units in operation, length of time, location, and type of application.

PART 2 - PRODUCTS

2.01 HARDWARE

A. Hardware shall be suitable for the environmental conditions and expected ambient temperatures within the Substation building and for 70°C within the switchgear cubicles.

B. Hardware shall withstand high electromagnetic fields, high levels of shock and vibration without malfunction.

C. All necessary control system electronics, operator control panel interfaces, self-protection, diagnostics, monitoring, and recording equipment shall be included. Sufficient memory shall be provided to store all required software and allow program expansion without hardware changes. The memory needs of the installed software shall utilize no more than 70% of the installed memory for each installed memory type.

1. IED software shall be stored in the processor memory such as RAM during operation.

2. As a backup, the IED program shall be stored in a non-volatile EPROM which shall provide maximum protection against program loss or program alteration due to battery drain, processor malfunction, or electromagnetic interference.

D. Input/Output (I/O) Units

1. All input and output signals shall be through isolation buffers. High voltage inputs and outputs shall be isolated external to the microprocessor-controlled device or IED. Isolation buffers shall:

a. Protect and isolate the control system from damage due to over-voltage, under-voltage, transients, shorts, and opens.

b. Perform necessary voltage translations.

c. Remove noise and undesired signals.

d. Limit, pre-process, discriminate and format those signals that would otherwise require excessive processor time.

2. Provide remote input/output (I/O) units with the following capabilities:

a. High-speed communication

b. Reduced interconnecting wiring

c. Central and distributed fault diagnostics

3. Provide all I/O units with high quality electronic terminators to allow the I/O modules to be changed without disturbing Substation wiring.

4. Mechanically "key" each I/O module to its base unit to allow only a module with the proper key code to be inserted in the base unit.

5. Provide I/O units with sufficient capacity for all inputs and output points as well as spare points equal to 25% of the total points.

E. Electronic Circuitry

1. Locate all control circuitry on printed boards inserted into a rugged printed circuit board frame.

2. Make all connections to the modules and to the frame via reliable pin and socket electronic connectors.

F. Operator Control Panel

1. Provide an operator control panel for each microprocessor-controlled device or PAC to monitor and display status and functions. Mount the panel in the front door of the associated cubicle.

2. The operator control panel shall be suitable for diagnostic purposes, for monitoring and modifying the substation function registers, and for checking or changing equipment parameters, such as modifying time settings and values of analog signals.

3. Furnish the operator control panel with an easy-to-use operator interface panel and display.

G. Enclosures

1. Enclosures shall be dustproof, rustproof, of high quality construction designed to protect the electronic equipment in an industrial environment that is not provided with air conditioning or humidity control.

2. Enclosures shall be equipped with a terminal for connection to the substation ground.

H. Surge Protection

1. Provide surge protection to comply with IEEE C.37.90.1

I. Power Supplies

1. Microprocessor-controlled devices and IEDs shall remain fully operational in the event of a substation ac power failure.

2. Power shall be derived from the Substation dc auxiliary power supply system either directly or via a suitable dc to dc inverter module.

2.02 PROGRAMMING SOFTWARE

A. Programming software shall be user-friendly PC Windows-based programming tools suitable for off-line program development.

B. The software shall be dedicated solely for creating control system programs. It shall use familiar, standardized editors bundled in a single application.

C. The software shall include a graphics editor and on-line help to simplify the development of ladder diagrams.

D. The software shall comply with Microsoft Windows Graphical User Interface (GUI) and IEC 61131-2 standards for programmable automation controllers.

E. Provide complete user documentation for the software.

2.03 GENERAL REQUIREMENTS FOR OPERATING SOFTWARE PROGRAM

A. Design the operating software using independent modules to control each protective function within each circuit breaker cubicle or section.

B. Design the operating software to interface with the Communication Interface Cabinet (CIC) and other devices located within the ac and dc switchgear.

C. Design the software with self-diagnostic routines to respond promptly, safely and predictably to detected faults. Send a hardwired common trouble alarm to the station HMI mounted in the SCADA interface terminal cabinet (SITC) in the event of a controller system malfunction or failure.

D. Provide system and input device failure monitoring and protection. Monitor all inputs for unsafe, erroneous, or unknown conditions or combinations of conditions.

E. Sample all input conditions at rates sufficient to detect and remedy all unsafe or damaging conditions in the shortest possible time. Sampling rates and program execution times shall be such that the control system is not the limiting factor in response to unsafe or damaging conditions. All software shall be designed to ensure that the timing requirements for safety-related tasks are always met.

F. Limit all output commands to safe levels regardless of any combination of input conditions.

G. Provide transient fault recording to capture analog and digital pre-fault and post-fault data to enable review of system history.

H. Provide control and monitoring of equipment during Substation set-up, commissioning, testing, and equipment checkout during maintenance.

I. Operating and application software shall correctly handle times and dates for the time span from calendar years 1990 to 2100 inclusive.

J. Software version numbers shall be included within the code. Multi-chip programs must self-test to assure that the correct complement of chips is installed. Software shall have verifiable version control based on a calculation cyclic redundancy check (CRC) polynomial published in the system documentation and verifiable using an approved utility to be provided with application software.

2.04 REQUIREMENTS FOR DEVELOPMENT OF NEW OPERATING SOFTWARE

A. All software developed under this contract, including source code, shall become property of VTA.

B. The Contractor shall utilize a Software Quality Assurance Plan in accordance with ANSI/IEEE Standard 730. The plan shall describe a mechanism for orderly software development.

C. De-bug and test software to the satisfaction of VTA before installing in switchgear, and beginning factory testing of the ac and dc switchgear.

D. Provide ladder logic diagrams, flowcharts, source code, and schematics for review and approval before installing in the ac and dc switchgear and factory testing. The diagrams shall be in sufficient detail to provide all information necessary to allow programming of the IED by VTA using the application software provided.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Microprocessor-controlled devices and IEDs shall be factory installed in the ac and dc switchgear in the circuit breaker sections or the negative switch section.

B. All interconnecting wiring shall be No. 14 AWG type SIS rated a minimum of 600 Vac, or type TC Cable as specified in Section 34 21 28 – Traction Power Wire and Cable.

3.02 SCADA AND ANNUNCIATION

A. Refer to Section 34 21 17– HMI and SCADA Interface Requirements.

B. Provide one trouble alarm window in the HMI Panel and one SCADA point for each microprocessor-controlled device or IED labeled "{Device Name} Trouble."

3.03 TESTING

A. Microprocessor-controlled devices or IED used in place of ANSI devices shall be factory design tested, factory production tested, and field acceptance tested, as specified in Section 34 21 63 – Testing and Commissioning for the ANSI device or devices they are replacing.

B. Each microprocessor-controlled device shall be burn-in tested in accordance with the following requirements:

1. Equipment shall be placed in an environmental chamber and cycled continuously between 0°C and 60°C.

2. Each cycle shall be 8 hours in duration. Maximum and minimum temperature shall be sustained for 3.5 hours in each cycle.

3.04 MANUFACTURERS

Acceptable manufacturers: Allen Bradley, General Electric, Siemens, or approved equal.

END OF SECTION 34 21 18

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SECTION 34 21 19

AC TRACTION POWER SWITCHGEAR

PART 1 - GENERAL

1.01 SUMMARY

A. This Section describes the requirements for the Traction Power Substation (TPSS) Metal Clad AC Switchgear to be provided and installed in all Traction Power Substations to supply power to the Traction Electrification Transformer-Rectifier Unit, and to the substation auxiliary power equipment.

B. This Section also describes requirements for the "T2" station service switchgear section. This section includes a single-phase dry type transformer.

C. The Metal Clad Switchgear shall conform to the requirements of ANSI C37.20.2, "IEEE Standard for Metal Clad and Station Type Cubicle Switchgear."

D. The AC switchgear "H2" Utility incoming section shall be coordinated closely with, and meet the requirements of Pacific Gas & Electric (PG&E). Contractor shall coordinate all requirements and services with PG&E including service applications. VTA shall be engaged in all correspondence.

E. The CT's and PT's for the utility's use shall be provided and installed by the utility power companies. "No load" type of PT disconnect switches shall be provided by the Contractor and shall be in accordance with PG&E requirements.

F. PG&E approval of the utility incoming section "H2" is required prior to manufacturing of this unit.

1.02 REFERENCE STANDARDS

Organization	Number	Title
ANSI/IEEE	C37.06	Ac High-Voltage Circuit Breakers Rated On Symmetrical Current Basis-Preferred Ratings and Related Required Capabilities
ANSI/IEEE	C37.12	Ac High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis – Specifications Guide

ANSI/IEEE	C37.20.2	IEEE Standard for Metal Clad and Station Type Cubicle Switchgear
ANSI/IEEE	C37.20.3	IEEE Metal-Enclosed Interrupter Switchgear
ANSI/IEEE	C37.46	Specifications for Power Fuses and Fuse Disconnecting Switches
ANSI/IEEE	C37.90	Surge Withstand Capability (SWC) Test
ANSI/IEEE	C39.1	Electrical Analog Indicating Instruments
ANSI/IEEE	C57.12	General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
ANSI/IEEE	C57.12.91	Dry-Type Distribution and Power Transformers
ANSI/IEEE	C57.13	Requirement for Instrument Transformers
ANSI/IEEE	C62.1	Surge Arresters for Ac Power Circuits
ANSI/IEEE	242	Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
EUSERC	400	Electric Utility Service Equipment Requirements Committee
EUSERC	407	Electric Utility Service Equipment Requirements Committee Guidelines, Section 400 and Drawing 407
IEEE	1653.2	Standard for Uncontrolled Traction Power Rectifiers for Substation Applications up to 1,500 Vdc Nominal Output
PG&E	Greenbook	Electric & Gas Service Requirements (TD-7001M) (2017-2018)
		Bulletin TD-2999B – Technical Requirements for Electric Service Interconnection at Primary Distribution Voltages

1.03 SUBMITTALS

A. Refer to Section 01 33 00 – Submittals. Note that utility company acceptance of submitted equipment will be required. Refer to PG&E Electric & Gas Service Requirements (Greenbook), for submittals required in accordance with Bulletin TD-2999B – Technical Requirements for Electric Service Interconnection at Primary Distribution Voltages.

B. Submit the following for approval within 30 calendar days after Notice to Proceed:

1. Certified overall dimension drawings showing the weight and dimensions of the switchgear line-up.

2. Technical data and catalog cuts on proposed ac circuit breakers, protective relay and breaker test station.

3. AC switchgear function block diagram including power metering network connections.

C. Submit the following for approval within 90 calendar days after Notice to Proceed:

1. Symbols and abbreviations used on all the submittals, all presented in one or two drawings

2. Single-line diagrams including metering and relaying

3. Ac circuit breaker control schematics

4. Auxiliary equipment control schematic

5. Ac equipment enclosure grounding protection schematic

6. Power meter equipment schematic

7. Breaker test station control

8. Equipment layouts and physical dimensions consisting of:

   a. Plan views

   b. Elevation views

   c. Sections

9. Technical data and catalog cuts on all remaining devices, equipment, and materials.

D. Submit the following for approval within 120 calendar days after Notice to Proceed:

1. Mounting details for ac switchgear enclosures
2. Locations of all control and protective devices, and meters
3. Section drawings of all equipment, showing accessibility for maintenance
4. Samples of the switchgear interior and exterior finish paints
5. Other drawings not listed herein before

E. Submit the following for approval within 150 calendar days after Notice to Proceed:

1. Connection diagrams of all equipment showing internal wiring and terminal block arrangement and identification of each outgoing power and control terminal. Show all devices in their respective physical locations. All terminal blocks and terminals to be uniquely identified show connections to existing equipment.
2. Interconnection diagrams of all equipment showing terminal blocks of individual units, interconnections between units, and connections to external equipment. Show all devices and their respective physical locations. All terminal blocks and terminals to be uniquely identified showing interconnection to existing equipment.
3. Equipment configuration and setting parameters including communication programming and interfaces.
4. Spare parts with the reference number for each item including the Contractor's and original manufacturer's part numbers.
5. Equipment, device, and component nameplate data.

F. Submit a protective device coordination study within 160 days after notice to proceed calendar. Refer to Specification section 34 21 00 – 1.12 for further requirements of the study content and approvals.

G. A Coordination Study shall be performed for the AC system of each Traction Power Substation to ensure that the protective devices will function together in conformance with ANSI/IEEE Standard 242, IEEE Recommended Practice for Protection and Coordination, latest version. The study shall meet the requirements of the utility power supply company and at a minimum include the following:

1. Proposed protective device coordination time-current curves for the ac system portion shall be graphically displayed on conventional log-log sheets.

2. Terminate device characteristic curves at a point reflecting maximum fault current to which device is exposed.

3. Identify device associated with each curve by manufacturer type, function, tap, time delay and recommended instantaneous settings.

4. Plot time-current characteristics for the following devices:

   a. Electric utility's protective devices

   b. Medium voltage equipment relays

   c. Pertinent transformer full-load currents at 100%, 150%, 300% and 450% as per IEEE 1653.2

   d. Transformer magnetizing inrush currents

   e. Transformer damage curve

   f. Ground fault protective device settings

   g. Co-ordination of TPSS auxiliary power distribution for both utility and generator supplies.

5. Study shall provide settings and coordination for a primary and an alternate utility supply if required by the Utility company.

H. An arc flash hazard analysis shall be performed for each traction power substation. The study shall meet the requirements of the utility power supply company and at a minimum include the following. Refer to section 34 21 00 – 1.12.B for requirements.

1.04 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed thereafter.

1.05 QUALITY CONTROL

Refer to General Conditions GC-47, Quality Assurance Program, for general requirements and procedures.

1.06 QUALITY ASSURANCE

Qualifications

1. Submit certification of at least five years successful experience in the planning, design, manufacture, assembly, installation, testing and commissioning of switchgear of similar type specified herein:

    a. Rated bus current 1,200 A minimum

    b. Rated nominal voltage 21 kV for TPSS #33, 21 kV for TPSS #34

2. Submit certification that the manufacturer of the ac switchgear assemblies for traction power service in accordance with ANSI C37.20.2 has manufactured equipment substantially equivalent to the equipment indicated in these Contract Documents. Demonstrate that this equipment has operated successfully in revenue service on rail transit properties for at least five years.

3. Submit certification that the manufacturer of the ac circuit breakers for traction power service in accordance with the latest revision of ANSI C37.06 and ANSI C37.12 has manufactured equipment substantially equivalent to the equipment indicated in these Contract Documents. Demonstrate that these circuit breakers have operated successfully in revenue service on rail transit properties for at least five years.

4. The certifications in items 1, 2, and 3 above shall each be substantiated with fully documented information and references.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. The ac switchgear shall form a line-up of dead front, free-standing switchgear suitable for indoor service. Access to all components shall be from the front and the rear. Equipment access panels located on the side, top, or rear of the enclosures are prohibited. The switchgear shall be totally enclosed and shall be metal clad and conform to the requirements of ANSI C37.20.2, except as otherwise indicated.

B. Make the switchgear, inclusive of all its equipment, operating environment devices, and materials, capable of being operated and maintained at the performance levels indicated, without impairment resulting from the impact of the environment, over the ranges and values indicated herein:

1. Ambient Outdoor Temperature: -5 to +42°C

2. Relative Humidity: 0 to 100 percent, including conditions of condensation

3. Elevation: Up to 100 feet above sea level

C. Seismic Requirements

1. The ac switchgear will be located at sites that will be subjected to seismic events. Seismic forces for switchgear anchorage to be in accordance with requirements of latest California Building Code.

D. Make required provisions for escape of gases from the compartment of the ac switchgear to the outside by means of louvered vent openings covered with grilles, and arranged in such a way that hot gases, hydrogen or other materials cannot be discharged in a manner hazardous to personnel or equipment including controls, materials, adjacent cubicles, etc.

E. The rear access doors of the ac switchgear shall be positioned to accommodate the watertight doors of the substation enclosure.

F. Provide warning and caution notes in operations, assembly, maintenance, and repair instruction; and distinctive markings on hazardous components, equipment, or facilities for personnel and public protection.

G. Make all equipment and components readily accessible for inspection, maintenance, adjustment, and reading of data. Mount all devices, including protective relays, from which data are to be read on the front panels. Mount all other devices to be readily accessible either on the surface of the equipment, or by opening a hinged door or panel, and without removing another device or equipment except by drawing out the circuit breaker.

H. Equipment as assembled for operation to have no openings which would allow the accidental entry of hand tools and the like. Control products of circuit breaker arcing in normal and fault clearing operations so that the substation structure and finish will not be jeopardized, and operating personnel will not be endangered or injured.

2.02 RATINGS

The AC switchgear shall have the following ratings:

	TPSS #33	TPSS #34
Nominal Voltage (rms)	21 kV	21 kV
Maximum Voltage (rms)	27 kV	27 kV
Rated Frequency, Hz	60	60

Insulation Level, Low Frequency Withstand (rms)	60 kV	60 kV
Insulation Level, Impulse Withstand (BIL)	125 kV	125 kV
Continuous Current	1200A	1200A

2.03 AC SWITCHGEAR STRUCTURE

A. The switchgear assemblies shall consist of rigid, self-supporting and self-contained, electrically welded, or bolted No. 11 gauge minimum steel structure.

B. Structural elements shall be electrically welded together. The structure shall be rigid and shall support equipment under normal loads, short-circuit conditions, and specified seismic conditions.

C. The switchgear enclosure shall be suitable for accommodation of drawout circuit breakers and shall include stationary disconnecting device contacts and supporting rails for the circuit breakers.

1. The design shall allow the circuit breakers to be easily drawn in or out of their housing and connected or disconnected from the buses and auxiliary circuits by means of self-aligning, self-coupling, primary and secondary disconnecting devices.

2. The devices shall be suitably shrouded or provided with automatic safety shutters to prevent accidental contact with live parts. Guide rails or cradles for positioning the removable elements shall be provided as an integral part of the equipment. Connection of control wiring to the ac breaker by a plug-style disconnect may be acceptable; provided the breaker cannot be mechanically racked into the connected position with the plug disconnected.

D. The ac switchgear enclosure shall be divided, barriered, and partitioned into three vertical sections. For the purpose of this specification, the sections are referred to as follows and as shown on the Contract Drawings:

1. AC Circuit Breaker Section

2. Utility Incoming Section

3. Auxiliary Power Section

E. Each compartment shall be provided with separate hinged front and rear access doors for servicing. Opening of any front door shall not expose circuits in adjacent compartments. Access doors on all enclosures shall have a sign stating "DANGER: LIVE PARTS" and "DANGER: HIGH VOLTAGE."

F. Protective relays, meters, instruments, and control devices shall be mounted on the front doors of the compartment.

G. Controls, including programmable controllers, instrumentation, control relays, terminal boards, control wiring, and control devices shall be housed in a separate control/terminal board compartment, barriered from the power wiring and buswork compartments. Exception: where controls and terminal boards are dedicated to circuit breaker function, they may be located in the circuit breaker compartment.

H. The doors shall be formed of No. 11 gauge minimum sheet metal and shall be properly reinforced against distortions by suitable flanges and stiffening members.

I. Hinges shall be a stainless steel heavy-duty type.

J. All doors shall be securely fastened in the closed position with a minimum of three latches easily opened without the use of tools. Two latches will be allowed if front panel consists of more than one full-length door.

K. Each door shall be provided with a handle and with stops to hold it securely in the open position.

L. Each circuit breaker housing shall be provided with protective shutters to cover live high- voltage terminals as the removable element of breaker is drawn out of the cubicle.

M. Heating strips, controlled by individual thermostats shall be provided in each cubicle. Individual thermostat in each cubicle shall be located in a general area such that cool air in the lower portion of the cubicle can be sensed by the thermostat.

2.04 UTILITY INCOMING SECTION

A. The Incoming Section is shown on the Contract Drawings as section H2 of the AC switchgear.

B. The section shall meet all the requirements of PG&E and be fabricated in accordance with utilities' standard drawing and approved by PG&E and VTA. In addition, clearance requirements must also be met as per PG&E "Green book" standards.

C. Provisions shall be made for bottom (underground) cable entrance, and termination of the 21 kV incoming service cables.

D. Utility Grounds: Provide 5/8" diameter 4" long grounding stud on each bus phase in the incoming line section.

E. Ground Bus: Provide a copper ground bus having a momentary rating not less than the highest momentary rating of the circuit breaker and extending the full length of the switchgear assembly. Ground each housing directly to this bus. Ground the frame of the circuit breaker through a ground contact shoe at all times, except when the primary disconnecting devices are separated, and the shutters closed. At all points of connection between the ground bus and the structure, remove all nonconductive coatings. At the utility metering cubicle, extend the ground bus into the utility potential transformer compartment in accordance with the utility's requirements.

F. Provisions shall be made for mounting of PT's and CT's in accordance with the utility's requirements. Provide "no load" PT disconnect switches in accordance with PG&E Greenbook Section 11 requirements as applicable. Coordination with the utilities, including determination of the exact service and metering instruments requirements, is the responsibility of the Contractor.

G. The Incoming Service Section shall be constructed of no less than No. 11 gauge sheet steel and shall be provided as part of the ac switchgear assembly at all substations.

H. The enclosure access door shall be hinged on one side and shall have a three-point latch mechanism padlockable by the utility. Access doors on enclosures containing revenue metering equipment shall be labeled: "UTILITY METERING CUBICLE: NO CUSTOMER EQUIPMENT."

I. A copper ground conductor equivalent to #2/0 copper minimum shall be installed around the inside of the enclosure walls in the cable termination compartment and shall be solidly grounded to the ac switchgear ground bus. A grounding post shall be installed for use with portable grounds.

J. Utility approval of the shop drawings is required prior to the manufacturing of the H2 cubicle. Contractor to verify the bottom-entry conduit locations to ensure proper termination of the utility incoming cables.

2.05 AC CIRCUIT BREAKER SECTION

A. The Circuit Breaker Section of the ac switchgear is shown on the Contract Drawings.

B. The circuit breaker shall be a draw-out type and utilize vacuum interrupters having load and fault break capabilities and shall conform to or exceed the requirements of ANSI C37.06 and ANSI C37.12.

C. Circuit breakers with the same rating shall be identical and physically and electrically interchangeable among all traction power substations.

D. The circuit breaker enclosure shall be provided with a manual racking mechanism for horizontal drawout with three positions: disconnected, test, and connected.

E. Interlocks shall be provided to prevent either electrical or manual operation of the breaker unless it is in the connected or test position. A positive mechanical interlock shall prevent racking in or out unless the breaker is in the OPEN position.

F. The breaker, complete with the operating mechanism shall be capable of being removed from the enclosure in the fully withdrawn position.

G. Positive stops shall be provided to prevent over travel.

H. Guides shall be provided to ensure proper alignment.

I. The circuit breaker frame shall be provided with a full front metal shield to prevent access to any live primary bus or load terminals when the circuit breaker is in the connected position.

J. When the breaker is in the connected and test positions, the case and frame shall be grounded by means of a positive contact with a copper ground bus.

K. Materials used for circuit breaker insulation shall be of a type that is noncombustible, non-hygroscopic, and track-resistant. The mechanical strength and physical characteristics shall match the stresses imposed by the circuit breaker rated momentary current.

L. Means shall be provided to permit padlocking the ac breaker in the open position to prevent inadvertent closure by other personnel.

2.06 CIRCUIT BREAKER

A. Minimum ratings:

	TPSS #33	TPSS #34
Nominal Voltage (rms)	21 kV	21 kV
Maximum Voltage 9rms)	27 kV	27 kV
Rated Frequency, Hz	60	60
Continuous Current	1200A	1200A
Insulation Level, Low Frequency Withstand (rms)	60 kV	60 kV
Insulation Level, Impulse Withstand (BIL)	125 kV	125 kV
Short-Circuit Level at Service Voltage	750 MVA	750 MVA

Interrupting Time (cycles, maximum)	5	5
Rated Short-Circuit Current	25 kA	25 kA

B. Operating Mechanism

1. The circuit breaker operating mechanism shall be motor-charged and spring-operated.

2. Tripping shall be accomplished by 125 Vdc control voltage from the station auxiliary power, and closing shall be accomplished by a 125 Vdc stored energy.

3. The mechanism shall be designed to prevent overcharging. The mechanism shall ensure that the release of stored energy for closing the circuit breaker main contacts is prevented unless the mechanism has been fully charged. The stored- energy closing mechanism shall automatically charge itself within 15 seconds after closing of the breaker. Energy storage shall be sufficient for an open-close- open cycle at maximum rated short circuit current.

4. The stored-energy mechanism to have enough energy for an open, zero second close and open duty cycle without recharging.

5. A white indicating light shall be located on the front of the circuit breaker enclosure to indicate the stored-energy closing mechanism is charged.

6. An interlock shall be provided to prevent the withdrawal of the circuit breaker from the enclosure when the mechanism is in the fully charged state. Automatic controlled discharge of the stored energy when the circuit breaker is withdrawn from or inserted into the enclosure will also be acceptable.

7. A manual cranking feature shall be included on the operating mechanism to permit spring charging in the event motor power is unavailable.

8. The circuit breaker shall be electrically and mechanically trip free. The operating mechanism shall be non-pumping.

9. A four-digit, non-resettable, register-type mechanical operations counter shall be provided on each circuit breaker to record each close/open cycle.

C. Circuit Breaker Control

1. The circuit breaker shall be designed for local electrical operation at the 125 Vdc control voltage. The closing mechanism shall be provided with a spring release coil, anti-pump relay, and spring charging motor suitable for operation

over a voltage range of ±15% of the nominal dc control voltage. The tripping mechanism shall be provided with a shunt trip coil suitable for operation over a voltage range ±25% of the nominal dc control voltage.

2. Each circuit breaker shall be provided with switchboard type heavy-duty pistol- grip control switch mounted on the front of the cubicle. The control switch shall permit the open and close operations when the circuit breaker is in the connected or test position. A switch shall be provided for resetting the circuit breaker via the ac lockout relay (Device 86-1) after a lockout trip, and a mechanical trip indication shall be provided at the control switch.

3. Indicating lights shall be located on the front of the circuit breaker enclosure to indicate the state of the circuit breaker. A red light shall indicate a closed breaker and a green light shall indicate a tripped or open breaker.

4. A minimum of six electrically separate sets of reversible auxiliary contacts shall be provided, in addition to those required for the circuit breaker control circuit. All auxiliary contacts shall be operated by the breaker mechanism in both the "connected" and "test" positions. All spare auxiliary contacts shall be wired to the outgoing terminal blocks.

2.07 BUSES AND CONNECTIONS

A. The main horizontal three-phase bus shall be fabricated from electrical grade copper and extend the full length of the switchgear.

B. The bus, including joints, shall be insulated the full length with flame-retardant, non-hygroscopic, track-resistant insulation over its entire length.

C. All connections, including bus taps, circuit breaker connections, connections to CT's and PT's and transformers, shall be bussed using the same material as the main horizontal bus with either silver plated copper, or tin plated aluminum and joined with a minimum of two bolts and Belleville washers per joint.

D. The continuous current rating of all main bus and circuit breaker connections shall be at least 1,200 A.

E. All buses and bus connections shall be adequate to withstand all thermal and mechanical stresses associated with short-circuit currents equal to the momentary and three-second rating of the circuit breaker.

F. A copper ground bus, not less than 2 x 1/4 inch, shall extend the length of the ac switchgear assembly, and be bonded to each switchgear section by solidly bolting the bus to a non-removable structural member.

G. All bolted joints shall be silver-plated and made with a minimum of two bolts.

2.08 AUXILIARY POWER SECTION

A. The switchgear section shall comply with ANSI C37.20.2, “IEEE Standard for Metal Clad and Station Type Switchgear.”

B. The bus compartment shall be in compliance with ANSI C32.20.02.

C. The main horizontal bus and the fuse holder shall be solidly bussed together.

D. Ratings:

	TPSS #33	TPSS #34
Nominal Voltage (rms)	21 kV	21 kV
Maximum Voltage (rms)	27 kV	27 kV
Rated Frequency, Hz	60	60
Continuous Current	600 A	600 A
Momentary Current	40 kA	40 kA
Integrated Short sym. Circuit Rating (rms)	25 kA	25 kA
Basic Insulation Level (BIL)	125 kV	125 kV

E. Power Fuses

1. Power fuses shall be current limiting and comply with the requirements of ANSI C37.46. Fuse selection shall ensure the fuses are capable of detecting and interrupting all faults up to the short-circuit rating of the ac switchgear assembly. Fusible elements shall be non-aging.

F. Station Service Transformer

1. The transformer shall be a single-phase, dry type, 115 degree rise, 25 kVA minimum rating and in compliance with ANSI C57.12, and shall be design tested in accordance with ANSI C57.12.91 inside the switchgear enclosure to determine maximum temperature rise.

2. The transformer shall be protected on the primary by draw-out fuses mounted on a withdrawal trunnion carriage. The trunnion shall be mechanically interlocked (i.e. Kirk-Key) with the low-voltage panel secondary main breaker ensuring that the load is removed prior to fuse trunnion withdrawal.

3. The transformer shall be mounted in the bottom of the rear compartment of the

switchgear section where it is easily accessible for maintenance. The access door to the rear transformer compartment shall have an interlock to prevent opening the rear door or access to live components or connections with the transformer energized. High voltage connections may be done with high voltage cable provided the cables are readily accessible and easily removed for maintenance.

4. The disconnect mechanism shall safely separate the fuses from the high voltage contacts prior to opening the front access door of the enclosure. It shall not be possible to open the front access door with the fuses energized.

5. The high voltage winding of the transformer shall be wound for a rated voltage of 21 kV and shall be furnished with a total of four 2-1/2% full capacity taps, 2 above and 2 below the rated nominal voltage.

G. Convection cooling, with an intake vent near the floor, and clear unobstructed flow of air through a metal mesh covered opening near the top of the ac switchgear shall be provided.

H. The transformer compartment(s) shall be equipped with a gasketed wire glass window to allow visual inspection of the fuses.

2.09 PROTECTIVE RELAYS

A. All protective relays shall be of the microprocessor-controlled or digital type and shall be flush mounted, with wiring connections on the back of the relay.

B. All protective relays, except for the microprocessor-controlled type, shall be provided with integral test switches.

C. Protective relays shall have rustproof metal or high-impact plastic rectangular cases. The finish shall be as approved by VTA.

D. Protective relays shall be furnished with hand-reset targets and seal-in units.

E. Contacts and adjusting devices shall be readily visible, accessible, and adjustable from the front of the relay. The relays shall have silver-to-silver non-welding contacts. All relays shall conform to the applicable sections of ANSI C37.90.

F. Devices including switches, relays, indicating lights, and test plugs shall be arranged to be conveniently accessible and easily visible. The grouping shall be modular and place related functions in proximity.

G. Devices shall be mounted plumb and square with the lines of the panels, and as recommended by the manufacturer. Relays or devices shall be mounted on hinged or removable panels, and shall not be mounted on a fixed portion of the switchgear.

H. Care shall be taken to avoid wiring congestion. All auxiliary devices shall match the general appearance as far as possible with frames of a compatible color.

I. Devices of the same general type shall be manufactured by the same company and shall be similarly arranged and mounted.

J. At a minimum, the following protective and monitoring devices shall be provided as shown on the substation one-line drawing in the Contract Drawings. Additional protective devices recommended by the Contractor or equipment manufacturers may be installed with the approval of VTA.

1. The AC Breaker protective relaying shall require both VTA and PG&E approval.

2. Phase Overcurrent Relays: The primary function of the phase overcurrent relays (Device 50/51) shall be to provide overload and fault protection for the rectifier and transformer. Relays shall be used to compile a composite time overcurrent characteristic curve which shall best match the normal and overload requirements of the rectifier and to match the thermal and mechanical withstand of the rectifier- transformer. Relay, (Device 50/51) shall provide for both instantaneous and time delay overcurrent protection. A back-up phase overcurrent relay is required.

3. Ground Overcurrent Relay: A residual instantaneous and time delay relay (Device 50/51N) shall be provided and connected in such a way as to provide sensitive ground fault detection. This relay shall be field adjustable. A back-up ground overcurrent relay is required.

4. Loss of Phase: The three-phase voltage protective relay (Device 60) shall be provided and connected in such a way as to provide open phase protection. This relay shall contain a field adjustable time delay.

5. Undervoltage: The primary function of the undervoltage relay (Device 27) shall be to annunciate an ac input voltage of less than 80% of the nominal voltage. This relay shall also annunciate a loss of voltage due to utility outage or main breaker opening. Undervoltage protection may be considered a monitoring relay function. This relay shall trip ac breaker (Device 52).

6. Overvoltage: An overvoltage relay (Device 59) shall be provided to protect against the overvoltage due to the failure of utility voltage regulation. This relay shall trip ac breaker (Device 52).

7. Ac Lockout: An ac lockout relay (Device 86-1) shall be provided for ac

breaker. A pistol-grip switch shall be provided for resetting of the ac lockout relay. Indication of "lockout" and "normal" shall be provided at the reset switch, as described in Section 2.06.C. A “trip coil healthy” indicating light shall also be equipped with the relay.

8. Door Interlock: Door interlocks (Device 33) shall be provided for the ac switchgear section enclosures except for the control panel compartments to prevent closing the ac breaker when the rear access door is open. Door interlocks shall be located at the doors of the ac switchgear section enclosures. Operation of Device 33 shall initiate local and remote annunciation.

2.10 INSTRUMENTS AND METERS

A. Instruments and meters shall conform to ANSI C39.1.

B. Ammeters and voltmeters shall be analog switchboard type, with 250 degree scales, rated for use with corresponding instrument transformers.

C. The cases shall be dustproof, with finish approved by VTA, and covered with a non-reflecting glass window.

D. The accuracy of all indicating instruments shall be within one percent of full-scale reading.

E. Voltmeters and ammeters shall be suitably rated for use with the corresponding transformer. Scales shall be of a suitable range, equal to the associated potential or current transformer primary rating.

F. Incoming line phase selector switches shall be provided for connection to the line transformers for the voltmeter.

G. A separate ammeter shall be provided for each phase.

2.11 INSTRUMENTS TRANSFORMERS

Instrument transformers shall conform to ANSI C57.13, with the following additional requirements:

1. Current transformers shall be molded-rubber or epoxy construction, wound-type, and installed in a compartment isolated from the control panel and all other equipment.

2. Current transformers shall be capable of withstanding thermal and mechanical ratings of the circuit breaker.

3. Current transformers shall have a mounting frame which bolts securely to the

switchgear frame. Transformers shall have full-wave impulse insulation level of 125kV depending on the system voltage at the substation. Secondary terminal blocks shall have covers with integral shorting bars, and secondary wiring shall be run to readily identifiable terminal block points in the control compartment. Terminal block points shall also have integral shorting bars for the current transformer leads.

4. Current transformers shall satisfy the requirements for relaying accuracy classification, under the burdens imposed by the devices specified herein.

5. Potential transformers shall be molded-rubber or epoxy construction. Transformers shall have full-wave impulse insulation level of 125kV depending on the system voltage at the substation. Primary and secondary circuits of all potential transformers shall be fused by means of non-renewable cartridge-type fuses. All primary fuses shall be completely disconnected before access can be obtained to either the transformer or its high- voltage fuses. The potential transformer shall be visibly grounded when the primary circuit is disconnected and in position for inspection. Secondary circuit fuses shall be installed in the low-voltage circuits and shall be located to permit replacement when the switchgear is in operation. All potential transformers shall be adequately rated in accordance with the burden requirements of the accuracy classification, and capable of carrying rated load continuously without excessive heating or damage.

2.12 POWER MONITOR

A. The Power Monitor shall monitor power received from the utility, including voltage and current for each phase, and watts, and vars. Coordinate with VTA Operations for any additional requirements, especially set-up and payments to 3rd party vendors.

B. The Power Monitor shall be an advanced socket-based energy and power quality meter. The meter shall be installed into the utility redundant meter socket. The Contractor shall be responsible for its configuration and integration of the meter into VTA network of existing power meters. The power meter shall be Schneider Electric ION 8650, or VTA approved equal.

C. The Power Monitor shall be microprocessor based, high performance and accuracy, high throughput, allowing real-time processing of information.

D. The display shall consist of easy-to-read alphanumeric characters which annunciate:

1. Four digit voltage display phase indication

2. Four digit amperage display

3. Eight digit power function display

E. The unit shall be configured to operate in Wye (Star), Delta, or Single phase voltage modes. The following measurements shall be provided:

1. Current on each phase
2. A fourth current input
3. Line to line voltages
4. Line to neutral voltages
5. Frequency
6. Power factor
7. KVA
8. KVAR
9. kW Demand
10. Vaux (Auxiliary Voltage Input)
11. Total MWhr
12. Total MVARhr

F. Minimum and maximum values for each of the readings shall also be available.

G. The unit shall be set to take snapshots of all readings at user-definable intervals and maintain them in non-volatile memory. The snapshot data is read using the serial communications output.

H. The unit shall be furnished with multimode fiber optic ports and shall also support optional plug-in communication cards which allow remote access to the device data. The unit shall support both RS-232C and RS-485 communications.

I. The power meter shall be provided with three control relays which may function as:

1. Alarm relays and setpoint relays which operate as a function of any measured parameter for demand, power factor, or load control
2. Remote control relays, operated by command via the communications bus

3. kWhr/kVARhr pulse outputs

J. The Power Monitor shall provide the following logging capabilities:

1. Event Log: This log records events such as power up, parameter changes, alarm conditions, relay changes, and status input changes. The 50 most recent events may be retrieved from this log. The event log can only be read using the communications option.

2. Snapshot Log: This optional log contains voltage, current, and all power values which are recorded at user-defined time intervals. The 100 most recent snapshots may be retrieved from this log using the communications option,

3. Min/Max Log: This log records the extreme values for voltages, currents, power, and other measured parameters. Min/Max data can be read using the integral display or using the communications option.

K. All log entries (events, snapshots, and min/max values) shall be time stamped to the second.

L. Ratings of the Power Monitor shall be as follows:

1. Voltage Inputs: 120 Vac nominal full scale input version

2. Overload Withstand: 1,500 Vac continuous, 2500 Vac for 1 Sec

3. Input Impedance: 2 Megohm

4. Aux. Voltage Input: 1.0 Vac/Vdc nominal full scale input (1.25 Vac/Vdc max.)

5. Overload Withstand: 120 V continuous, 1,000 V for 1 Sec

6. Input Impedance: 200 Kohm

7. Current Inputs: 5 Amps ac nominal full scale input

8. Overload Withstand: 120 V continuous, 1,000 V for 1 Sec

9. Input Impedance: 0.05 ohm, Burden

10. Control Relays: Form C dry contact relays (R1, R2, R3), 120 Vac or 24 Vdc @ 10 Amp maximum load current

11. Operating Temperature: 0°C to 50°C (32°F to 122°F) ambient air

temperature range

M. Voltage, Current, Status, Relay and Power Inputs all pass the ANSI C37.90A surge withstand and fast transient tests.

N. The Power Monitor shall be supplied with software capable of displaying data on a Windows based Personal Computer. User manuals, 8 hours of training, and instruction materials shall be provided.

O. The Contractor shall furnish and install all electrical, mechanical hardware, cables, conduits, connectors, converters, and other accessories to provide a fully functioning power monitoring system that is integrated with VTA's existing Power Monitor network for monitoring at remote workstations.

2.13 CONTROL SWITCHES

A. All control switches shall be of the rotary heavy-duty cam type, suitable for panel mounting with rectangular front panel engraved escutcheon plates showing switch positions.

B. All breaker control switches shall have pistol-grip handles or approved equal, and shall be provided with mechanical indicating devices to show the last operation of the switch.

C. All instrument selector switches shall have round knurled handles. Lockout relay switches shall have pistol grip handles. Switches shall be installed so mating contact surfaces are vertical.

D. Refer to Section 34 21 01 – Traction Power Basic Electrical Materials and Methods, for switch ratings and additional requirements.

2.14 TEST SWITCHES

A. Provide test switches for all ammeters and voltmeters, and between all instrument transformers, both current and potential, and the protective relays supplied by these transformers.

B. Mount each test switch group in a semi-flush case of uniform size, capable of holding at least six current positions and four voltage positions.

C. A convenient dull black dust cover to permit covering the test switches and contacts when they are not in use.

2.15 AC SURGE ARRESTERS

A. Surge arresters shall be coordinated with the utilities characteristics and furnished and connected in an approved manner which will protect the transformer and the rectifier from excessive voltage surges caused by lightning strikes and other types of surges which may occur on both the ac and dc systems.

B. The arresters shall be mounted to maintain the required clearances for the voltage class from any adjacent metallic enclosure.

C. Ac surge arresters shall be 27 kV intermediate class metal oxide disk type and comply with the requirements of ANSI C62.11.

2.16 AC BREAKER TEST STATION

A. A circuit breaker test station shall be provided for the ac switchgear.

B. The test station shall be capable of closing and tripping the ac breaker.

C. The test station shall be wall mounted and equipped with sufficient length of umbilical cord for connecting to the breaker.

D. The front panel of the test station shall be furnished with the following:

1. A control switch to open and close the breaker
2. A red LED indicating light for breaker "Closed"
3. A green LED indicating light for breaker "Open"

PART 3 - EXECUTION

3.01 MANUFACTURE

The metal clad AC switchgear shall be manufacturer in accordance with the reference ANSI Standards, and Section 34 21 01 – Traction Power Basic Electrical Materials and Methods.

3.02 INSTALLATION

AC Switchgear Installation: AC switchgear shall be installed in accordance with Section 34 21 16 – Traction Power Substations.

END OF SECTION 34 21 19

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SECTION 34 21 20

DC TRACTION POWER SWITCHGEAR

PART 1 - GENERAL

1.01 SUMMARY

A. This Section describes the requirements for designing, manufacturing, furnishing, and installation of the dc switchgear to be provided in traction power substations.

B. Provide line-up of dc switchgear consisting of the following minimum individual vertical sections:

1. Negative Switch Section

2. Main Breaker Section

3. Feeder Breaker Sections

C. Number of circuit breakers and the configuration of each Traction Power Substation, to be provided are shown of the Contract Drawings.

1.02 REFERENCE STANDARDS

Organization	Number	Title
ANSI/IEEE	C37.14	Low Voltage Dc Power Circuit Breakers used in enclosures
ANSI/IEEE	C37.16	Preferred ratings, related requirements and application recommended for LV Power Circuit Breakers
ANSI/IEEE	C37.20.1	IEEE Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear
ANSI/IEEE	C62.11	Standard for Metal Oxide Surge Arresters

1.03 SUBMITTALS

A. Refer to Section 01 33 00 – Submittals.

B. Submit the following VTA’s approval within 30 calendar days after Notice to Proceed:

1. Certified overall dimension drawings showing the weight and dimensions of the switchgear line-up

2. Technical data and catalog cuts on proposed dc circuit breakers, protective relay annunciator/HMI panel, and lightning arrester

C. Submit the following for approval within 90 calendar days after Notice to Proceed:

1. Symbols and abbreviations used on all the submittals, all presented in one or two drawings

2. Single-line diagrams including metering and relaying

3. Dc main and feeder circuit breakers control schematics

4. Auxiliary equipment control schematic

5. Dc equipment enclosure grounding protection schematic including tie-up to existing protection devices

6. Annunciator/HMI control and logic schematic

7. Transfer trip schematic diagrams between adjacent substation dc feeder breakers

8. Equipment layouts and physical dimensions consisting of:

    a. Plan views

    b. Elevation views

    c. Sections

9. Technical data and catalog cuts on all remaining devices, equipment, and materials

D. Submit the following for approval within 120 calendar days after Notice to Proceed:

1. Connection diagrams of all equipment showing internal wiring and terminal block arrangement and identification of each outgoing power and control terminal. Show all devices in their respective physical locations. All terminal blocks and terminals to be uniquely identified show connections to existing equipment.

2. Interconnection diagrams of all equipment showing terminal blocks of individual units, interconnections between units, and connections to external

equipment. Show all devices in their respective physical locations. All terminal blocks and terminals to be uniquely identified show interconnection to existing equipment.

3. Protective device range and setting calculations showing basis on which each relay is set. Submit protective device coordination curves showing coordination of all equipment. Plot of rectifier design capability to be included with actual margin of coordination (from breaker trip to design capability) clearly indicated for each of 150, 300, and 450 percent full-load current and short-circuit current. Include coordination between minimum setting of the rate-of-rise relay and maximum current due to accelerating trains. Submit all manuals for the protective devices with the protective device range and setting calculations. Coordination study shall include the status all relay setting parameters, setting philosophy as well as the above described curves.

4. Spare parts with the reference number for each item including the Contractor's and original manufacturer's part numbers.

5. Equipment, device, and component nameplate data

6. Shop (installation) drawings to scale showing the lightning arrester installation

1.04 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed thereafter.

1.05 QUALITY CONTROL

Refer to General Conditions GC-47, Quality Assurance Program, for general requirements and procedures.

1.06 QUALITY ASSURANCE

A. The Contractor shall submit certification of at least five years successful experience in the planning, design, manufacture, assembly, installation, testing and commissioning of switchgear of similar type specified herein. Dc switchgear of similar type is defined as follows:

1. Rated current shall be 4,000 A minimum

2. Prospective short circuit current 158,000 A minimum

3. Nominal voltage 800 Vdc

B. Submit certification that the manufacturer of the dc switchgear assemblies for traction power service in accordance with ANSI C37.20.1 has manufactured equipment substantially equivalent to the equipment indicated in these Contract Documents. Demonstrate that this equipment has operated successfully in revenue service on rail transit properties for at least five years.

C. Submit certification that the manufacturer of the dc circuit breakers for traction power service in accordance with the latest revision of ANSI C37.14 and ANSI C37.16 has manufactured equipment substantially equivalent to the equipment indicated in these Contract Documents. Demonstrate that these circuit breakers have operated successfully in revenue service on rail transit properties for at least five years.

D. The certifications in Items A, B, and C above shall each be substantiated with fully documented information and references.

E. Dc Switchgear shall be UL labeled or certified as conforming with the requirements of UL and ANSI from a third party Independent Testing Laboratory (ITL) recognized by the State of California.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. The dc switchgear shall from a line-up of dead-front, ventilated, metal-enclosed, free-standing, sheet steel enclosures suitable for indoor service.

B. Access to removable components of the switchgear shall be from the front. Bus and power wiring access shall be from the front or rear.

C. The switchgear shall be equipped with individually-enclosed, high-speed power circuit breakers rated for use with the Transformer-Rectifier Units.

D. The main switching and interrupting device of the dc breakers shall be of the removable type arranged for moving physically between connected, test, and disconnected positions.

E. Each switchgear assembly shall also include dc buses and connections, positive and negative feeder cable terminal connections, indicating lights, terminal blocks, protective and auxiliary relays, control circuitry, wiring, and all other devices necessary to make a complete and operable assembly. All designs, materials, construction, and tests shall be in accordance with ANSI C37.14 and C37.20.1 and as further described or modified herein.

F. Operating Environment

Make the switchgear, inclusive of all its equipment, devices, and materials, capable of being operated and maintained at the performance levels indicated, without impairment resulting from the impact of the environment, over the ranges and values indicated herein.

1. Ambient Outdoor Temperature: -5 to +42°C

2. Relative Humidity: 0 to 100 percent, including conditions of condensation

3. Elevation: Up to 100 feet above sea level

G. Seismic Requirements

Enclosures and equipment will be located at sites that will be subjected to seismic events. Seismic forces for design of the substation enclosures and for equipment anchorage to be in accordance with requirements of latest California Building Code.

2.02 RATINGS

The switchgear assembly and circuit breaker shall have the following minimum ratings in accordance with ANSI C37.16.

	TPSS	
	Main Breaker	**Feeder Breaker**
Full-Load Voltage	800 Vdc	800 Vdc
Maximum Voltage	1,000 Vdc	1,000 Vdc
Continuous Current	6,000 A	4,000 A
Minimum frame size	6,000 A	4,000 A
Insulation Level:	**Main &Feeder Breakers**	
60 Hz withstand	4.6 kV, rms	
Short circuit rating	158 kA, rms	

2.03 SWITCHGEAR ENCLOSURE

A. The switchgear steel structure shall be rigid, self-supporting, self-contained conforming to ANSI C37.20.1 and to the requirements indicated.

B. The assemblies shall be fabricated of electrically welded or bolted No. 11 gauge minimum steel. The enclosures shall be sufficiently rigid to support equipment under normal loads and short-circuit conditions and specified seismic conditions.

C. The switchgear enclosure shall be suitable for accommodation of drawout circuit breakers and shall include stationary disconnecting device contacts and supporting rails for the circuit breakers.

D. The design shall allow the circuit breakers to be easily drawn in or out of their housing and connected or disconnected from the buses and auxiliary circuits by means of self-aligning, self-coupling, primary and secondary disconnecting devices.

E. The devices shall be suitably shrouded or provided with automatic safety shutters to prevent accidental contact with live parts.

F. Guide rails or cradles for positioning the removable elements shall be provided as an integral part of the equipment.

G. Connection of control wiring to the dc breaker by a plug-style disconnect is acceptable, provided the breaker cannot be mechanically racked into the connected position with the plug disconnected.

H. Each compartment shall be furnished with a hinged door or full width drawout panel for front access to the circuit breakers, disconnect switches, instruments, and terminal blocks. In addition, where rear access is provided, rear access doors shall be provided to facilitate access to the rear compartment for regular cleaning. Doors shall be able to swing fully open against the adjacent door or enclosures. The dc power bus shall be installed and accessible from the front or rear compartment. Connections to the dc outgoing feeder cables shall be housed in the rear compartment.

I. Doors shall be formed of No. 11 gauge minimum sheet steel and properly reinforced against distortion by suitable flanges and stiffening members.

J. Hinges shall be heavy-duty stainless steel. All doors shall be securely fastened in the closed position with a minimum of three latches easily opened without the use of tools. Two latches will be allowed if the front panel consists of more than one full-length door. Each door shall be provided with a handle and with heavy duty stops to hold it securely in the open position.

K. Access doors on all enclosures where 800 Vdc wiring is present, shall have a sign stating “DANGER: LIVE PARTS” and “DANGER: HIGH VOLTAGE.” Additionally, rear access shall be outfitted with ¼ inch removable plastic panels inscribed, “DANGER: HIGH VOLTAGE.”

L. Each enclosure shall be provided with protective shutters that cover live high-voltage terminals when the access door is opened, or a dc feeder breaker/main dc breaker is racked out to the cubicle.

M. Enclosures shall be constructed to allow adequate clearance to ground and for the dissipation of ionized gas from the circuit breaker arc chutes without hazard to personnel or possibility of establishing a conducting path to grounded structure or objects when interrupting maximum short-circuit energy at rated maximum voltage.

N. Adequate provisions shall be made for release of gas from the units to the outside by means of suitable stacks, louvered vent openings or vent openings covered with grilles, and arranged in such a way that hot gas or other materials cannot be discharged in a manner hazardous to personnel.

O. Enclosure surfaces exposed to arcs or ionized gases shall be lined with flame resistant, high dielectric insulating materials.

P. The enclosure shall be completely insulated from ground and from the rectifier transformer and the ac switchgear. A low-resistance frame fault relay shall be connected between the structure and the ground mat.

Q. All high voltage devices shall be separated from low voltage controls and readily identified by color coding mounting panel.

R. No controls are allowed in rear cable and bus compartment.

S. Dc switchgear, rectifier, and negative switch shall be insulated and isolated from the floor, walls, and the ac switchgear using an epoxy floor covering and electrical laminate as described in Section 34 21 16– Traction Power Substations.

T. Thermostatically-controlled strip-type heaters shall be provided in each cubicle to prevent condensation. Heating shall operate at 50% of their voltage rating. Each cubicle shall have its own individual thermostat and be located in a general area of each cubicle so that cool air at the lower portion of the enclosure can be sensed by the thermostat. Heaters shall be supplied power via an isolation transformer rated at 5 kVA minimum.

U. Switchgear assembly surfaces to be painted shall be cleaned and otherwise prepared for painting by a three-step process consisting of an alkaline wash, phosphatizing and an acid wash, or other equal process recommended by the paint manufacturer and approved by VTA. Provide for future touch-up one gallon each of the approved exterior and interior paints with each substation delivered.

2.04 NEGATIVE DISCONNECT SWITCH – 89N

A. Each substation dc switchgear assembly shall contain a dc negative disconnect switch mounted in negative switch enclosure as shown in the Contract Drawings. The negative disconnect switch (Device 89N) shall be installed between the rectifier negative output and the negative bus.

B. The negative disconnect switch shall be rated to carry 6,000 A continuous current at 1,000 Vdc and withstand the bolted short-circuit currents of 50,000 A.

C. The insulation level shall be sufficient to pass a 60 Hz withstand test at 4.6 kV, rms.

D. The main dc circuit breaker and negative disconnect switch shall be interlocked to ensure the operation of negative disconnect switch only under no-load.

E. The negative disconnect switch shall be a bolted-pressure type, manually-operated, single-pole, jaw-pressure-type, solid copper blade with silver plated contacts with an insulated operating handle.

F. The negative disconnect switch shall be key interlocked with the positive main dc circuit breaker to prevent opening of the negative switch unless the main breaker is open, and similarly, prevent the main breaker from closing unless the negative switch is closed.

G. The front panel of each enclosure shall be provided with a green indicating light, which shall be illuminated when the negative disconnect switch is open, and a red light shall be illuminated when the switch is closed. The indicator shall be wired to an auxiliary contact on each switch that is isolated from the 800 Vdc bus.

H. The negative switch shall be provided with a simple operation instruction nameplate on the door.

2.05 NEGATIVE DRAINAGE EQUIPMENT

The following shall be provided in the Negative Switch Section:

1. The negative drainage equipment shall include the negative drainage disconnect switch. The negative drainage equipment shall be housed in the Negative Drainage Panel and shall be clearly and permanently labeled “Negative Drainage Panel”.

2. The negative drainage disconnect switches shall be manually operated, single pole, single throw, 100A, 2000 volt copper blade with silver plated contacts. The switches shall be equipped with insulated operating handles.

3. The negative drainage panel enclosure shall be insulated from ground and grounded items and shall include the disconnect switches and space for the reverse current diodes, bus and bus connections, surge arrester, shunts, meters and other devices required to make a complete and operable assembly.

4. The panelboards shall have high mechanical and dielectric strength.

5. Approved material shall be provided on which to mount the drainage disconnect switches and related devices and equipment.

6. Provide busbar for connection of at least four negative drainage cables. The panels shall be sized to accommodate the connection of drainage cables and diodes.

7. The panels shall be impervious to moisture, and able to withstand high temperatures without damage.

8. The reverse current diode shall be rated at 300 A, 2 kV, and capable of conducting ground fault currents for the time required for the feeder breakers to open.

2.06 HUMAN MACHINE INTERFACE (HMI) PANEL

The main HMI panel shall be flush mounted on the Communication Interface cabinet. Individual display/HMI for each multifunction microprocessor protective device shall be installed flush on its associated equipment control cabinet door of the DC switchgear. Refer to Sections 34 21 17 and 34 21 18.

2.07 FEEDER AND MAIN DC CIRCUIT BREAKERS

A. The circuit breakers shall be a single-pole, air-break, high-speed, removable type. The circuit breakers shall be manufactured in accordance with ANSI C37.14 and rated according to the preferred ratings listed in ANSI C37.16, except as modified herein.

B. Circuit breakers shall be suitable for local and remote supervisory control.

C. The circuit breakers shall be electrically operated and electrically and mechanically trip- free with the mechanism insuring full contact pressure until time of opening.

D. All circuit breakers shall be insulated to withstand 4.6 kV, rms at 60 Hz. The rated short- circuit current of feeder and main breakers shall be 158 kA, minimum. The instantaneous and sustained current curves shall be set to limit the contact wire thermal rise to the less than the specified maximum value.

E. The circuit breakers shall be designed for control from the 125 Vdc control power bus. The closing mechanism shall be operable over a voltage range of 145 to 90 volts. The tripping mechanism shall be operable over a voltage range of 155 to 75 volts.

F. 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.

G. Circuit interruption arc chutes shall be of the metal plate of magnetic coil type, suitable for bi-directional current flow and designed for positive interruption of all currents within the circuit breaker ratings. Arc chutes may be furnished with an air puffer device, if required to positively extinguish low current arcs.

H. Contact surfaces of the moving and stationary contact members of the main contacts shall be silver, non-welding silver alloy, or equivalent which combines high conductivity and necessary arc-resistant properties.

I. Circuit breakers shall be provided with approved wheels to remove element from cubicle. A fifth wheel shall be provided to assist in moving breaker element within substations.

J. Removable elements of the same type and rating shall be completely physically and electrically interchangeable. Removable elements not of the same type of rating shall not be physically interchangeable.

K. The operating mechanism shall be solenoid-operated, magnetically actuated or motor-charged, stored-energy, spring-operated type. The mechanism shall be non-pumping and the design shall ensure positive opening of the moving contacts and circuits interruption when the tripping impulse is received at the fully closed or any partially open position. Control shall be provided with a shunt trip device with the necessary auxiliary control equipment.

L. Mechanisms that are motor-charged and spring-operated shall meet all requirements of Section 34 21 19 – AC Traction Power Switchgear.

M. Solenoid-operated mechanisms shall be connected such that the control voltage is removed from the closing coil after a preset time. In the event the breaker does not close, or the closing control circuit is not opened, a trip sequence shall be initiated to open the closing control circuit and restore all closing sequence relays to their normal position.

N. A heavy-duty switchboard type pistol-grip control and remote/local switches rated in accordance with Section 34 21 01 – Traction Power Basic Electrical Materials and Methods.

O. Red and green long-life high brightness and high visibility LED array indicating lights shall be provided on each breaker unit for electrical closing and opening of the breaker while in the “test” or “connected” positions. The red indicating light shall be illuminated when the breaker is closed and the green indicating light shall be illuminated when the breaker is open.

P. Local/remote switch shall have a white LED mounted above the switch shall illuminate when switch is in local position.

Q. Provisions shall be made for moving each breaker to a “connected”, “test” and “disconnected” position with positive stops in each position. In the “connected” position, both the primary disconnecting devices and the secondary disconnecting devices shall be in full contact and the breaker shall be in position for normal operation. In the “test” position, the primary disconnecting devices shall be open and separated by a safe distance and the secondary disconnecting devices shall be in full contact. In the “disconnected” position both the primary and secondary disconnecting devices shall be open and separated by a safe distance. Mechanical interlocks shall be provided to prevent moving the circuit breaker in or out of the “connected” position when the circuit breaker main contacts are in the closed position. An indicator shall be provided to show the location of the circuit breaker in “connected”, “test” or “disconnected” positions. Each breaker compartment and circuit breaker combination shall be provided with mechanical interlocks that shall prevent closing the circuit breaker manually unless the breaker is in the “test” or “disconnected” position. The circuit breaker shall be prevented from closing electrically, unless the circuit breaker is in the “connected” position with the primary disconnecting devices in full contact, or in the “test” position.

R. Secondary disconnecting devices by means of plug connectors and an umbilical cord are acceptable provided cables used with the connectors are harnessed properly to prevent any damage due to the movement of the breaker assembly. There shall also be interlocks to prevent removing the breaker from the cubicle while the secondary is connected.

S. Each circuit breaker shall be provided with mechanical means for manually tripping the circuit breaker when in the “test” and “connected” positions. This function shall be available with the compartment door closed. A mechanical indicator, visible when the door is closed, shall be provided to show when the circuit breaker is in the “open” and “closed” condition.

T. A minimum of six electrically separate sets of reversible auxiliary contacts shall be provided, in addition to those required for the circuit breaker control circuit. All auxiliary contacts shall be operated by the breaker mechanism in both the “connected” and “test” position. All auxiliary contacts, both used and spare, shall be wired to the outgoing terminal blocks and terminated at the control panel compartment of circuit breaker enclosure.

U. Means shall be provided to permit padlocking the circuit breaker in the open position to prevent inadvertent closure by other personnel without having to withdraw the breaker element.

V. A four-digit, non-resettable, register-type mechanical operations counter shall be provided on each circuit breaker to record tripping operations.

W. The request to close any dc feeder breaker shall be governed by the load measure reclose system. The substation shall be provided with sufficient logic to ensure any response to a remote closure request will not result in an unsafe condition or cause damage to the substations or any of its components. Manual bypass shall be provided in the event there is a failure with the reclosure relay. In addition, a manual means shall be provided to disable the auto-reclosure function.

X. All devices furnished under this Contract that have electrical opening or closing functions shall be provided with additional terminations within their respective control relay enclosures for connection to the remote supervisory control system.

Y. The instantaneous series trips of dc main breakers shall be responsive only to reverse current.

Z. The instantaneous series trips of the dc feeder breakers shall be responsive to forward current flows. Make the series trips adjustable from 100 to 400 percent of the rated continuous current of the circuit breakers without changing the trip modules. Protective relays shall trip bi-directional.

2.08 BUS AND BUS CONNECTIONS

A. The main horizontal dc switchgear bus shall be an extension of the rectifier bus and run the length of the dc switchgear, and tapped to serve each of the circuit breakers.

B. The dc switchgear bus shall be made of electrical grade copper.

C. The dc main bus shall be rated at 6,000 A.

D. Bus and bus connections shall be of adequate strength to withstand all thermal and mechanical stresses resulting from the maximum available rms short-circuit current without damage or permanent distortion, and shall not be less than the rms interrupting rating of the circuit breakers.

E. Bus bars shall be mounted on barrier-type insulation or post-type insulators of sufficient strength and braced to withstand, without damage or permanent distortion, all stresses produced by the maximum available short-circuit currents.

F. The enclosure shall be provided with a copper ground bus, ¼ inch by 2 inches minimum, for electrical bonding of the dc switchgear and attachment of the frame fault relay (Device 164/164G).

G. All bolted bus connections, including bus taps and circuit breaker connections, shall be silver plated copper and joined with a minimum of two bolts and Belleville washers per joint.

H. Each joint 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 switchgear.

I. All connections to the bus shall be bolted. The bolts shall be cadmium-plated, galvanized or similarly coated, high-strength steel bolts of sufficient number and size for application.

J. Insulate main bus in each compartment from feeder bus.

K. Provision shall be made for future extension of the main bus for the installation of future circuit breakers.

2.09 MIMIC BUS

Provide mimic bus with color coded red across the entire front of the switchgear. Continuously integrated mimic bus factory applied to front of switchboard. Arrange in single-line diagram format, using symbols and lettered designation consistent with approved final mimic-bus diagram. Coordinate mimic-bus segments with devices in switchboard sections to which applied. Produce a concise visual presentation of principal switchboard components and connections.

2.10 DC CABLE CONNECTIONS

A. The positive and negative dc feeder cables shall leave through the bottom of the switchgear in the power bus compartment as indicated.

B. Ample space shall be provided for pulling and terminating the feeder cables entering or leaving the switchgear without requiring a greater than specified cable bending radius.

C. Provisions shall be made for the termination of up to six 500 kcmils, 2 kV dc positive cables in each feeder breaker section, and connection to the dc lightning arrester conductors.

D. The load side of the negative disconnect switch shall provide for the termination of up to eight 500 kcmils, 2 kV dc negative return cables.

2.11 PROTECTIVE DEVICES

A. Microprocessor controlled or digital protective multi-function relays and devices equipped with communication functions shall be furnished, wired, and connected as indicated on the Contract Drawings. Additional components such as auxiliary relays, isolating diodes, and similar devices not shown in the drawings, but required for a complete installation, and also addressed in Section 34 21 18 shall be provided as specified herein.

General requirements include:

1. Screens: LCD
2. Alarm communication: send alarms to HMI/PAC via protocol specified in Section 34 21 18.
3. Built-in functions:
    a. Control
    b. Measurement
    c. Fault recording: Capture real-time voltage and current for triggered event with pre- and post-trigger sampling data useful for analyzing trip information.

B. Devices such as auxiliary relays, indicating lights, and test plugs shall be arranged to be conveniently accessible and easily visible.

C. The grouping shall be modular and place related functions in proximity. Devices shall be mounted plumb and square with the lines of the panels and mounted as recommended by the manufacturer and approved by VTA.

D. Care shall be taken to avoid wiring congestion. All auxiliary devices shall match the general appearance as far as possible with frames of a compatible approved color and finish.

E. Devices of the same general type shall be manufactured by the same company and shall be similarly arranged and mounted.

F. At a minimum, the following protective devices shall be provided as shown on the substation single line diagram in the Contract drawings. Additional protective devices recommended by the Contractor or equipment manufacturers may be installed with VTA approval. Refer to Substation Single Line Diagram on the contract Drawings for arrangement of protective relays and devices.

1. Overcurrent

    Provide each dc feeder circuit breaker with a direct-acting instantaneous overcurrent trip device and with an adjustable rate-of-rise overcurrent trip device. The rate-of-rise relay (Device 150) shall be bi-directional and shall have the following characteristics:

a. Instantaneous overcurrent

b. Inverse short-time overcurrent

c. Rate-of-rise with adjustable operating characteristic trip for remote low- level faults and for discriminating against tripping from train accelerating currents

d. Long-time overcurrent, for protection against thermal over temperature of the overhead contact and messenger wires and positive feeder cables

e. Readouts in LEDs including dc current and voltage

f. Operate on a nominal supply voltage range from 24 to 125 Vdc

The minimum short-circuit current will be 1,800A. Peak starting train current, lasting approximately 8 seconds, will be approximately 1,300 A per car. Simultaneous starting of two (2) 3-car trains (7800 amps @ 975 amps/sec) to be considered when setting the rate-of-rise relays.

2. Load Measuring and Reclosure

Equip each dc feeder circuit breaker with a set of automatic re-closing functions including a load measuring network consisting of a load measuring re-closing device (Device 182), voltage sensing device (Device 183), load measuring contactors. The automatic re-closing equipment including the load measuring network to function as follows:

a. The load measuring circuit to be activated only when the feeder breakers are in the connected positions and before the circuit breaker closes or attempts to close. When activated, the circuit shall measure the voltage of the circuit on the load side of the circuit breaker. The circuit breaker shall close only when the bus supply voltage is above 500 Volts dc. Load measuring circuit to prevent the circuit breaker from closing if the circuit measurement indicates a fault on the load side of the circuit breaker. The acceptable range which includes the train loads shall be adjustable. If a fault is indicated, the load measuring circuit shall make a specific number of attempts to close and then if not successful the circuit shall be automatically deactivated resulting in the feeder breaker to be removed from the re-close position until manually reset by a close command initiated either locally or remotely. Load measuring relay to properly compensate for voltage drop in the feeder circuit using suitable sampling and memory devices. Contractor's load measuring scheme to be submitted to VTA for approval.

b. The automatic re-closing circuit to be activated immediately after the circuit breaker has been tripped by its own overcurrent series trip or by all the rate-of-rise relay protective functions. Reclosing shall not be permitted when a circuit breaker is tripped by the local control switch or station lockout relay. Number of automatic re-closing attempts to be adjustable, one to six attempts. Initially re-closing circuit to be set for only one re-closing attempt. The circuit to be deactivated if the closure of the circuit breaker does not occur within preset attempts. The circuit to remain deactivated until reset by a new close command of the circuit breaker. The new close command can be initiated by either local control or remote supervisory control. Provide an enable-disable toggle switch in the breaker control compartment to permit disabling of the automatic re- closing function.

c. The load measuring resistors (maximum of 25 ohms) to be rated for repeated operations and mounted on top of the dc switchgear. Circuit breaker may be subjected to repeated operating cycles due to a malfunction of another control device such as a supervisory control system. The load measuring circuit to operate only if the circuit breaker is in the connected position. Means to be provided to disconnect the load measuring circuit from the 800 Volt dc potential whenever the circuit breaker is in either the test or disconnect position.

3. Low Resistance Frame Fault

a. The dc switchgear, rectifier enclosure and negative switch enclosure shall be insulated from the Substation building floor and any adjacent grounded equipment. The enclosure shall be single point grounded through a separate low resistance ground relay (Device 164/164G) by means of an insulated #4/0 AWG copper conductor connected directly to the Substation ground mat. The 164/164G relay shall be the only ground path to the enclosure and the occurrence of any other ground path must be detected and shall trip and lock-out the Substation.

b. Device 164/164G to annunciate upon detection or sensing of energized or grounded structure, rectifier, dc switchgear or negative drainage equipment. Annunciation shall be via auxiliary relays as required.

c. When Device 164 senses a current equal to or greater than 0.07 A, Device 164X to trip and lockout the incoming main ac breaker and all dc feeder breakers. In addition, Device 164 is not to permit voltage to exceed 50 Vdc on the structure under “worst case” fault conditions.

4. Transfer Trip – Provision shall be made, as indicted in Contract Drawings, for

initiating transfer tripping between feeder circuit breakers located at substations supplying power to the same section of an overhead contact system (OCS). Transfer trip functions and characteristics shall be as follows:

a. Each dc feeder circuit breaker shall be provided with a bi-directional transfer-trip relay (Device 185), to transfer trip between the circuit breakers located on each end of an OCS section. The OCS section between these circuit breakers is defined as a tripping zone. When a fault is detected in the tripping zone by the protective relays located at either end of the zone, the transfer trip relay shall initiate tripping of the remote circuit breaker.

b. Transfer trip may be initiated by either the rate-of-rise device functions, by the instantaneous series trip device, by dc enclosure alive auxiliary relay device, emergency trip relay, and fire detector as indicated on the Contract Drawings. Load measuring and reclosing shall be allowed with a transfer trip if tripped by the rate-of-rise (Device 150) or series trip device (Device 176).

c. Each transfer trip circuit between adjacent substations shall match the existing transfer trip at the adjacent substations and shall be supervised continuously by either a current or potential auxiliary relay, device No. 185X, furnished with contact for remote supervisory annunciation. This device shall be provided at the receiving end of each transfer trip circuit, and means shall be furnished at the sending end to adjust the value of supervision current in the circuit.

d. Tripping by the station lockout relay shall defeat load measuring and reclosing of both the local and remote circuit breakers. Provide transfer trip disable switch for purposes of disabling the transfer trip function.

e. Trip signals to remote circuit breakers shall be transmitted through existing copper pilot wires which shall be continuously monitored both locally and remotely. Failure of this signal shall be indicated on the annunciator panel and OCC via SCADA.

f. Only the tripping zone in which the fault has been detected shall be de-energized.

g. Provide all necessary wiring and equipment required in the substation for the specified operation of the transfer tripping system.

h. By-pass provision shall be made for carrying the transfer tripping function on to the next substation when any feeder breaker has been removed from service. The bypass switch shall be panel mounted.

i. Contractor to provide all necessary wiring, relays, and pertinent equipment required to interface with existing transfer trip system at adjacent existing substations and the new switchgear. Contractor to submit transfer trip scheme for interfacing with existing transfer trip circuits.

j. Provide a wall-mounted transfer trip interface cabinet complete with terminals as follows:

1) Transfer trip internal wiring up to the terminal blocks in the interface terminal cabinet shall be by Contractor. Contractor to submit a layout of the terminal blocks identifying each interface terminal.

2) Route the existing pilot wires from the existing transfer trip junction box to the new cabinet.

5. Reverse Current

The main dc circuit breaker shall be provided with reverse current detection (Device 32). This protection shall detect current flow from the distribution bus into the rectifier unit, and trip and lock out the main dc circuit breaker. The trip level shall be field adjustable by VTA maintenance and initially set to 15% of the rated current or as approved by the VTA.

6. Negative Rail Grounding System

a. General: Contractor shall furnish and install a floating negative grounding system device consisting of dc potential and current monitoring circuits and a high current silicon controlled rectifier (SCR) connected to provide uni-directional control of current flow. The negative rail grounding unit shall provide the automatic grounding of the negative by the gate turn-off thyristor (GTO) when the rail to ground voltage exceeds the safe set limit of the negative grounding overvoltage relay (Device 159G). Components of the floating negative grounding system are indicated in these Contract Documents for general function only. Contractor is required to provide a functional system and may provide a microprocessor unit with integrated functions including the GTO tripping log function subject to VTA's approval.

b. Operation: The floating negative grounding system shall operate in accordance with the logic as below. Contractor to submit the logic diagram for VTA's approval.

1) The negative grounding overvoltage relay (Device 159G) shall continuously check the negative to ground voltage. When the negative to ground voltage exceeds the preset safe value, the time delay relay (Device 162-1) shall trigger the thyristor gate to ground the negative system. The setting of relay (Device 159G) may be set on the order of 50 volts.

2) Subsequent to a short delay timer (Device 162-3), upon sensing a decrease in current, the contacts of Device 150G, instantaneous current relay, provide a gate turn-off signal to the thyristor device to resume its normal position of an ungrounded system.

3) Should the current continue to flow in the case of a positive to ground fault, the preset time delay by the Device 162-2 timer device shall trip all dc feeder breakers via the Device 162-2X auxiliary relay contacts with an alarm condition of system ground fault.

4) Dc feeder breakers shall automatically close through the load measuring protective relay scheme except for the faulted feeder circuit breaker, thus providing a positive indication of the faulted circuit.

c. Enclosure: Negative Rail grounding unit shall either be integrated with the Negative Switch enclosure or with a stand-alone enclosure located in an appropriate location in the substation. If a stand-alone enclosure is used, it shall be a rigid, equipped self-supporting, self-contained, metal- enclosed structure with hinged doors for access to the negative grounding equipment.

d. Logic Control Circuit: Logic control circuits shall consist of the following:

1) All logic control circuits shall be mounted on plug-in printed circuit boards and shall be constructed so that the printed circuit boards are interchangeable with other negative grounding units.

2) The logic control circuits shall be electrically isolated from the SCR and shall be designed so that an ungrounded oscilloscope or other test instruments may be connected to the logic control circuitry for maintenance purposes. The printed circuit board shall provide test points to facilitate performance testing.

3) All logic control circuits shall operate in a fail-safe mode with means provided for continuous monitoring. In the event of a malfunction, the SCR shall be triggered on continuously until the malfunction is cleared. Alarms shall be provided for indications or malfunctions as indicated in the alarm panel.

4) Printed circuit boards for the logic control circuits shall be of flame-resistant epoxy-glass material equipped with gold-plated contacts and a location slot (key).

5) The printed circuit board shall have a finish coating of clear epoxy paint (or similar non-tracking lacquer) on both sides to prevent "tracking" between circuit conductors and to secure components to the board.

e. Cooling: The SCR shall be mounted on suitable heat sinks and be convection cooled only. The size of the heat sink shall be in accordance with the performance rating as specified above at the maximum ambient temperature of the operating substation.

f. Alarms: Alarms listed below shall be grouped and alarmed in the station HMI/PAC, and also transmitted to the OCC via SCADA, as "negative grounding device failure."

1) 125 Vdc power supply status (Power source status)

2) Logic power supply (Internal power supply status)

3) Negative system potential (Visual indication of the voltage between the negative system and ground)

4) Overvoltage (Indication of a valid overvoltage condition. Once activated, the overvoltage indication shall remain on until manually reset)

5) Overcurrent (Indication of a valid overcurrent condition. Once activated, the overcurrent indication shall remain on until manually reset

6) Logic failure (Indication of a self-checking logic circuit failure)

7) Operation counter (Non-resettable counter with four digits which advance every time a valid operation of the floating negative grounding unit occurs)

g. Thyristor Ratings:

1) 1,200 A continuous

2) 1,000 Vdc peak reverse voltage

7. OCS Voltage Monitoring

a. Each dc feeder circuit breaker shall be provided with an OCS voltage monitoring relay (Device 127L) to indicate whether an OCS section is energized. The OCS voltage monitoring device shall be integrated with the existing OCS feeder disconnect switch. Complete wiring shall be provided, and OCS section energization shall be monitored by SCADA. The OCS voltage monitoring relay shall have one terminal connected directly to the OCS through a dropping resistor on an OCS pole located outside the TPSS and another terminal connected to the negative bus of the TPSS.

b. The ohmic value of the dropping resistor shall be in the 600 k-ohm to 1000 k-ohm range. Contractor shall determine the exact value of the dropping resistor and shall coordinate this with VTA.

c. The OCS voltage monitoring relay shall pick-up at a minimum voltage level of 300 Vdc and shall maintain the “OCS Energized” status until the voltage level drops to below 80% to 90% of the pick-up level, subject to approval by VTA. The relay shall meet the following criteria:

1) Relay output shall consist of several form-c dry contacts for local and remote indication of the status of the monitored OCS section, as shown on Contract Drawings.

2) Relay shall be rated for a minimum operating voltage level of 125 Vdc.

3) Relay shall be properly coordinated and function flawlessly with the circuit protection devices at the OCS pole, including the surge arrester.

4) Relay shall withstand without any damage or malfunction transient voltages of a magnitude no less than the residual voltage on the surge arrester and the clamping voltage of the zener diode.

5) The relay shall be of a substantially similar design or design derivative of a relay proven in service in traction power substations for at least 3 years. Relays shall conform to the

applicable sections of ANSI C37.1.

8. Surge Arresters

   a. The dc surge lightning arresters shall be installed in the dc switchgear in accordance with lightning arresters manufacturer's instructions.

   b. Dc surge lightning arresters shall be located in the rear compartment of the dc switchgear and shall be separated from the dc switchgear enclosure such that the arresters will fail in a safe manner.

      1) The arresters shall be connected with short leads to the ac ground mat.

      2) Protection shall be placed around the arresters so that in the event of a failed arrester, damage to the switchgear will be minimized.

      3) Adequate ventilation shall be provided for discharge of ionized gas.

   c. Dc surge lightning arresters shall be indoor style, intermediate class, and shall be designed, constructed and tested in accordance with the general requirements of ANSI C62.11.

   d. Dc surge lightning arresters shall be of the metal oxide varistor type.

   e. The arresters shall be rated to withstand normal operating line transients of up to 5,000 Vdc of either polarity to ground.

   f. The minimum sparkover voltage of the arrester shall be 2,000 V.

   g. The arresters shall limit the reverse voltage across the Rectifier silicon diodes to a value less than 75% of the peak-reverse-voltage rating of the diode by limiting the rise of the transient on the positive to negative bus.

   h. Substation arresters shall be connected between the negative bus and the ac ground mat, and between each ac feeder termination in each circuit breaker cubicle and the dc ground mat as shown in the substation single line diagram.

9. Door Interlock

   a. Door interlocks (Device 33) shall be provided for the dc switchgear section enclosures except for the control panel compartments to prevent closing the main ac circuit breaker and main dc circuit breaker when the rear access door is open.

b. Door interlocks shall be located at the rear doors of main dc circuit breaker and feeder breaker enclosures.

c. Door interlocks shall be located at both the front and the rear doors of negative switch enclosure.

d. Operation of Device 33 shall initiate local and remote annunciation.

10. Lock-out Relay

a. A dc lock-out relay (Device 86-2) shall be provided as indicated herein and on the Contract Drawings.

b. The lock-out relay shall be manual reset with a mechanical target as part of the nameplate; black for reset, orange for trip.

c. The lock-out relay shall consist of multiple decks of independent contacts for tripping, indications, closing and lockout of circuit breakers.

d. The lock-out relay shall be furnished with a red pistol-grip handle for hand-reset.

e. The lock-out relay shall be furnished with a "trip coil healthy" indicating light.

2.12 INSTRUMENTS AND METERS

Instruments and meters shall be solid state devices, of the highest quality.

9. Ammeters and voltmeters to be switchboard stand-alone analog type. The cases shall be dustproof, with an approved color and finish, and covered with a non- reflecting glass window. The accuracy of all indicating instruments shall be within one percent of full-scale reading.

10. All instruments for measuring at dc values shall receive their inputs from isolation converters that shall be furnished and mounted within the bus compartment of the switchgear. Suitable isolation and insulation shall be provided in order to assure safe operation in contact with personnel. All auxiliary devices required for operation of the converters shall be furnished.

11. A stand-alone ammeter and voltmeter shall be provided at the upper front

compartment panel of each feeder breaker enclosure.

a. Ammeter scale shall be in the range of 4,000 A. Voltmeter scale shall be 0 - 1,000 V.

12. An ammeter and a voltmeter shall be provided at the upper front compartment panel of the main dc circuit breaker enclosure.

    a. Ammeter scale shall be in the range of 6,000 A. Voltmeter scale shall be 0 - 1,000 V.

13. An ammeter shall be provided at the upper front compartment panel of the negative switch enclosure.

    a. Ammeter scale shall be in the range of 6,000 A.

14. Ammeters and voltmeters shall be operable independent of the microprocessor-based relays.

2.13 CONTROL PANEL COMPARTMENTS

A. Control panels shall be dead-front and shall consist of hinged swinging panels mounted on the switchgear frame.

B. The swinging panels shall be so constructed that they shall support flush and semi-flush mounted devices and shall not distort from a plane surface in any position.

C. The swinging panels shall be supported by stainless steel hinges, which shall allow the panels to swing open and provide free access to the area behind the panel, the rear of the devices mounted on the panels, wiring, terminal blocks, and auxiliary devices mounted within the compartment.

D. Swinging panels shall be secured in the closed position with two (2) positive latching or screwed fasteners that can be operated by hand without tools.

E. Panels shall open 90° and be held with heavy duty stops.

F. No 800 Vdc shall be present on swinging panels.

G. Provide lighting inside the control panel, that activates when the doors are opened, as required below:

1. General: Ceiling and side-mounted, LED strip luminaire with clear, prismatic diffuser, complying with UL 8750.

2. Minimum illuminance: 30 footcandles at 1.5 feet

3. Correlated Color Temperature: 5000 – 6000 K
4. Size: 30 centimeters or 12 inches long with 12 LEDs
5. MTBF: 50,000 hours

2.14 DC BREAKER TEST STATION

A. A circuit breaker test station shall be provided for the dc switchgear.

B. The test station shall be capable of closing and tripping the main dc breaker.

C. The test station shall be capable of closing and tripping the feeder breaker.

D. The test station shall be wall mounted and equipped with sufficient length of umbilical cord for connecting to the breaker.

E. The front panel of the test station shall be furnished with the following:

1. A control switch to open and close the breaker
2. A red LED indicating light for breaker “Closed”
3. A green LED indicating light for breaker “Open”

PART 3 - EXECUTION

3.01 MANUFACTURE

The switchgear unit shall be manufactured in accordance with the referenced ANSI standards, and Section 34 21 01 – Traction Power Basic Electrical Materials and Methods.

3.02 INSTALLATION

The switchgear shall be installed in accordance with Section 34 21 16 – Traction Power Substation Buildings.

3.03 PROTECTIVE DEVICE COORDINATION

Final setting of relaying systems and protective devices shall be established during the systems and acceptance tests specified in Section 34 21 63 – Testing and Commissioning.

3.04 SETTING OF NEGATIVE RAIL GROUNDING UNIT

The Contractor shall set the negative rail grounding device as described in the field acceptance tests specified in Section 34 21 63 – Testing and Commissioning.

END OF SECTION 34 21 20

SECTION 34 21 23

TRACTION POWER TRANSFORMER-RECTIFIER UNIT

PART 1 - GENERAL

1.01 SUMMARY

This Section describes the Work necessary to provide the Traction Power Transformers (TPT) and rectifiers, which are referred to in this specification as the "Transformer – Rectifier Unit" for the traction power substations.

The dry type traction power transformer shall be of either vacuum pressure impregnation (VPI) or encapsulated construction.

1.02 REFERENCE STANDARDS

Organization	Number	Title
ANSI/IEEE	C34.2	Practices and Requirements for Semiconductor Power Rectifiers
ANSI/IEEE	C57.12.01	General Requirements for Dry-Type Distribution and Power Transformers
ANSI/IEEE	C57.12.91	Test Code for Dry-Type Distribution and Power Transformers
ANSI/IEEE	C57.18.10	Standard Practices and Requirements for Semiconductor Power Rectifier Transformers
ANSI/IEEE	C62.11	Standard for Metal Oxide Surge Arresters
ASTM	D116	Vitrified Ceramic Materials for Electrical Applications
EIA	RS-282	Silicon Rectifier Diodes and Stacks
IEEE	1653.2	Standard for Uncontrolled Traction Power Rectifiers for Substation Applications up to 1,500 Vdc Nominal Output
NEMA	SG-6	Power Switching Equipment
NEMA	TR1	Transformers, Regulators and Reactors

1.03 SUBMITTALS

A. Refer to Section 01 33 00 – Submittals

B. Submit the following product data within 30 days of NTP for the approval of VTA, in accordance with the VTA:

1. Manufacturer's product descriptions, catalog data and information concerning design and application ratings, service, performance and reliability.

2. Manufacturer's arrangement, outline dimensions, and detail drawings for each item of transformer-rectifier unit and interphase transformer, including transformer insulation system details and documents confirming the Substation system rating.

3. Wiring, elementary, connection diagrams, and nameplate details.

4. Transformer and power rectifier circuit diagrams.

5. Bus and Bus insulators.

6. Transformer winding insulation system.

7. Relays, protective devices, control switches, over temperature devices and failed diode failure device.

8. Transformer enclosure latch assembly.

C. Submit the following shop drawings within 120 days of NTP for VTA's approval:

1. Transformer Nameplate Drawing.

2. Transformer Outline Drawing showing dimensions front, back and side elevations of enclosures, overall dimensions, lifting lugs, and transformer data including weight, impedance, primary and secondary BIL.

3. Transformer Primary and Secondary Busing Arrangements showing bus construction details and bill of materials.

4. Transformer Temperature Monitor Schematic and Wiring Diagram

5. Transformer tap changer arrangement details.

6. Transformer and rectifier anchorage details.

7. Transformer enclosure and door details.

D. Submit the following calculations within 90 days of NTP for VTA's approval:

1. Transformer design calculations, including hottest spot temperature ruse per ANSI C57.12.01.

2. Transformer calculation of winding temperature during a short circuit per ANSI C57.12.01.

3. Bus sizing calculations.

4. Seismic calculations for equipment anchorage.

5. Proof the transformer rectifier design and construction conforms to ANSI 519.

6. Product data and shop drawings of the interphase transformer.

7. Transformer-rectifier design calculations including DC voltage regulation.

E. Quality Conformance Certification.

1.04 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed thereafter.

1.05 QUALITY CONTROL

Refer to General Conditions GC-47, Quality Assurance Program, for general requirements and procedures.

1.06 QUALITY ASSURANCE

A. Qualifications

1. Submit certification of at least five years successful experience in the planning, design, manufacture, assembly, installation, testing and commissioning of similar type products specified herein:

a. Traction Power Rectifier (Extra heavy traction duty)

1) 2.5 MW, 800 Vdc

b. Traction Power Transformer (Extra heavy traction duty)

1) 2.5 MVA, 21 kV, 3-phase, 60Hz primary

2. Demonstrate that these products equipment have operated successfully in revenue service on rail transit properties for at least five years.

3. The Traction Power Transformer (TPT) and the Interphase Transformer shall be UL labeled or certified as conforming with the requirements of UL and ANSI from a third party testing laboratory recognized by the State of California.

4. The rectifier shall be UL labeled or certified as conforming with the requirements of UL and ANSI for metal enclosed switchgear, or as otherwise certified by a third party testing laboratory recognized by the State of California.

PART 2 - PRODUCTS

2.01 TRANSFORMER-RECTIFIER UNIT

A. Provide each transformer rectifier unit consisting of a separate traction power transformer and rectifier, as shown on the Contract Drawings. The units shall be complete with auxiliaries; controls; wireways; interconnecting ac and dc buses; enclosures; and all necessary hardware, wiring and devices. The units shall be complete, with all equipment, from the high voltage side of the transformer to the dc bus connections to the dc switchgear and negative enclosure. Except as otherwise specified, the transformer rectifier shall conform to ANSI C34.2, C57.12.01, C57.12.91, IEEE 1653.2 and NEMA TR1, and EIA RS-282 where applicable.

B. The transformer rectifier units shall convert 21 kV, 60 Hz, effectively grounded, 3 phase, 3 conductor primary power to 800 Vdc at 100 percent of full load. The transformer rectifier units shall receive ac power from the 21 kV ac metal clad switchgear. The dc output of the rectifier units shall feed the metal enclosed dc switchgear that controls and protects the power supply to the light rail Overhead Contact System.

C. The transformer rectifier units shall be rated 2,500 kilowatts, as shown on the Contract Drawings, measured at 800 Vdc at the rectifier output terminals. The transformer rectifier shall be 12 pulse, double-way, in accordance with ANSI C34.2, Circuit No. 31. Other technical characteristics shall be:

1. Loading Condition: Design the transformer rectifier units to meet the duty cycle specified in IEEE 1653.2 for extra heavy traction power service, defined as follows:

a. The transformer rectifier units shall be capable of operating continuously at 100 percent of rated load amperes until constant temperatures have been reached by all parts of the transformer rectifier units.

b. After constant full load temperatures are reached, the transformer rectifier units shall be capable of operating at 150 percent of rated load amperes for 2 hours and a superimposed cycle of overloads consisting of five periods of 1 minute each at 300 percent of rated load amperes followed by one period of 450 percent of rated load amperes for 15 seconds at the end of the period.

2. Efficiency: The overall efficiency of each transformer rectifier assembly shall be greater than 98 percent at its continuous rating.

3. Power Factor: The displacement power factor of each transformer rectifier assembly shall be 0.95 or greater from 25 percent to full load at rated ac voltage.

4. Regulation: With the nominal voltage maintained at the transformer primary and the transformer set at the rated voltage tap, the transformer-rectifier unit total regulation for the dc bus voltage shall be as follows:

Loading	Dc Bus Voltage
Output No load	870
100% full load	800

From full load to 450 percent of full load, the regulation shall be five percent linearly. Manufacturing tolerances shall not exceed ten percent of this value. Submit voltage regulation calculations prior to fabrication for VTA's review and approval.

5. Dummy Load: Limit the no-load voltage to the value specified. Provide a bleeder resistance dummy load, if required, to prevent excessive voltage rise at no-load.

D. Provide protection against transient surge voltages on both the ac and the dc side of the rectifier. If fuses are used in suppression networks, they shall be monitored by visual indicators and equipped with devices capable of monitoring by remote HMI.

E. Short Circuit Ratings

1. Design transformer, including terminal connections and buswork, to withstand a full short circuit with shorted low-voltage terminals, and rated voltage on the high-voltage terminals, in accordance with ANSI-C57.12.01. The duration of the short-circuit current shall be a least one second.

2. Design all parts of the rectifier unit, including the terminal connections and buswork, to withstand a maximum dc fault on the dc positive bus, without damage, for the time period required for the back-up protection to operate and open the ac circuit breaker.

F. The audible sound level for the transformer rectifier assembly including its interphase transformer, housed in its enclosure with all panels bolted, measured 3 feet away from the assembly, shall not exceed 60 dBA at 100% load.

2.02 TRACTION POWER TRANSFORMER

A. Provide either vacuum pressure impregnation (VPI) or encapsulated dry-type traction power transformers, mounted in a suitable, ventilated enclosure for indoor installation. The transformer shall be self-cooled, 21 kV primary, 3 phase, 60 Hz, suitable for indoor service at the IEEE 1653.2 extra heavy traction power duty cycle as described in 2.01.C.1. Acceptable manufacturers and brands shall be either VPI or UNIClad encapsulated dry type transformer manufactured by Virginia Transformer or approved equal.

B. The encapsulated low and high voltage windings shall be vacuum and pressure processed coils sealed in epoxy.

C. A flexible polyester insulation system shall be provided to allow coils to withstand mechanical and thermal shocks.

D. Circular coil constructions shall be provided for short circuit and impact loading strength.

E. The transformer core shall be constructed of high grade non-aging silicon steel laminations with magnetic permeability and low hysteresis and eddy current losses.

F. High-voltage and low-voltage windings shall be copper. The high-voltage winding shall be delta-connected, with insulation ratings as per below. The low-voltage windings shall be 45 kV BIL and suitably connected for 12-pulse rectifications. The windings shall not absorb moisture and shall be suitable for both storage and operation in adverse environments, including prolonged storage in 100 percent humidity at temperature from -30 degree C to 40 degree C. Winding insulation shall be a service proven 220 degrees C class. High voltage winding ratings shall be utility supply voltage dependent as follows:

1. 21kV Utility Voltage: High-voltage winding shall be 27kV class with a minimum of 125kV BIL.

G. Temperature Limits: The transformer average temperature rise shall not exceed the following ratings at a 40°C average ambient temperature, at the following ratings and conditions. In addition, the transformer shall not suffer any loss of life when operated at the specified duty cycle.

H. Winding Connections: High and low voltage winding connectors to ac switchgear and the rectifier shall be made by copper bus with braided copper connections on the transformer end to reduce bus vibration.

Traction Power Transformer
Maximum Temperature/Current

Load in Amperes	**Average Temperature Rise**	**Maximum Hot-Spot Temperature Rise**
150% Nameplate Rating	120°C	150°C
Nameplate Rating	65°C	95°C
Two-Hour Overload	135°C	165°C

I. Select the transformer impedance to provide the rectifier output voltage specified.

J. The high-voltage windings shall have six 2.5 percent, full capacity off-load taps, three above and three below the nominal rated voltage of 21 kV as follows:

1. Tap changing shall be by movable silver-plated copper bus links.
2. Taps shall be brought out and rigidly supported on a terminal board located at the side of the transformer, not the top.
3. Jumpers from the transformer taps to the tap changer board and primary bus shall be insulated for 21 kV as required and kept as short as possible so as to not interfere with access to the coils for maintenance of cleaning.
4. Tap connections shall be accessible through removable access panels.
5. Access panels shall have an ample sized, wired glass, gasketed observation window for observing the tap connections.
6. The marked tap connections shall be identified so that the tap selected is clearly visible through the observation window.
7. Securely bolt the tap-changing bus links in position.
8. 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.

K. The traction power transformer shall be connected to the ac switchgear on the high voltage side using electrical grade copper bus with silver plated joints. The bus shall be securely supported from the transformer frame by electrical porcelain insulators that conform to ASTM D116. Insulators shall be rated for the line-to-line voltage application, free of imperfections. Insulators that have been re-touched with paint will be rejected. The bus shall be sized for mechanical strength and ability to withstand a bolted fault without distortion, ¼ inch by 2 inches minimum.

L. The traction power transformer shall be connected to the rectifier on the low voltage side using electrical grade copper bus with silver plated joints. The bus shall be securely supported from the transformer frame by electrical porcelain insulators that conform to ASTM D116. Insulators shall be rated for the line-to-line voltage application, free of imperfections. Insulators that have been re-touched with paint will be rejected.

M. The bus shall be sized for mechanical strength and ability to withstand a bolted fault without distortion.

N. The bus shall be sized for a current density of 750 amperes per square inch, or a maximum temperature of 90 degrees C at a 40 degree C ambient. Cable jumpers from the secondary taps on the coil to the secondary bus shall be rated for 90 to 105 degrees C maximum at IEEE 1653.2 Extra Heavy Traction power service loading. Jumpers shall be insulated for 7.5 kV at 133% insulation level at the maximum bus design temperature, 90 or 105 degrees C.

O. Transformer Temperature Monitor

1. The Transformer Temperature Monitor shall incorporate a hot spot winding temperature indicator. The hot spot location shall be that of the highest temperature reading obtained during the System Design testing.

2. Display temperature continuously on a digital display of the unit:

a. Accuracy: Within 1.5 percent of the full-scale reading.

b. Scale: Degrees Celsius.

c. Peak Temperature:

1) Peak temperature shall be displayed when requested by the activation of a front panel mounted pushbutton.

2) Peak temperature shall be resettable via a separate front panel

mounted pushbutton.

3) The unit shall store the peak temperature reached by the traction power transformer.

3. Provide NEMA 1 enclosure for low voltage terminals. The enclosure shall be hinged or screw cover with a white enamel back panel. Mount terminal strips on the back panel and mount the panel securely to the transformer frame. Provide barriers to separate conductors with different voltage insulation ratings, such as thermocouple wiring and 125 Vdc control wiring.

4. Mount the enclosure in a location readily accessible from the front as indicated, but not to restrict access to the transformer coils for maintenance. Do not mount the enclosure in removable panels.

5. All control wiring shall be 2,000 volt type SIS, number 14 minimum, except for thermocouple wiring. All contacts shall be electrically separate and shall be suitable for operation at 125 Vdc. All control wiring shall be enclosed in galvanized GRS steel conduit, and securely strapped to the transformer frame with ¼" x 20 HHMS except as otherwise provided.

6. Design the control wiring for maximum ambient design temperature in accordance with IEEE 1653.2.

P. Transformer Enclosure and Base

1. Design the transformer so that parts which require maintenance are readily accessible from the front, and that the bottom and top of coils are readily accessible for cleaning without removing buswork, panels, or obstructions of any kind.

2. The ventilation louvers shall be designed for maximum cooling from the bottom to top.

3. The transformer shall be enclosed in a rigid, self-supporting and self-contained, electrically welded or bolted, indoor steel enclosure. The structure shall be sufficiently rigid to withstand maximum transformer short circuit currents without deformation. The entire front of the transformer shall open by pad- lockable hinged double doors secured by three point latches. The rear of the transformer shall be accessible from the outside by removable panels with stainless steel handles and lifting means. The panels shall be secured with 3/8 inch minimum stainless steel tamper-proof machine screws tapped into machined bosses.

4. The transformer front doors shall be provided with heavy duty dc rated limit switches which shall be connected to the trip and lockout ac breaker and the main dc breaker whenever the front door is opened (Device 33T).

5. Design the transformer base from structural steel members suitable for rolling or skidding in any direction. Make provisions for pulling along the centerlines perpendicular to each side. Provide jacking facilities at each of the four corners of the base to permit insertion of rollers between floor and base. Base construction shall firmly secure the core to prevent relative motion of the core during shipment, handling, or seismic shock. Lifting shall be done from the top of the transformer. Provision for lifting from the bottom shall also be provided.

6. Design the transformer mounting to minimize vibration.

7. Use bolted straps and stainless steel fasteners throughout. Tie wraps are prohibited.

8. Provide lifting hooks or eyes on the transformer frame with a safety factor of four to facilitate lifting the unit from the top. Provision for lifting from the bottom shall also be provided.

9. Provide the traction power transformer with a corrosion-resistant metal nameplate marked in accordance with ANSI C57.18.10 and securely fasten to the front of the enclosure.

    a. The rating plate shall indicate the type of conductor used for both high voltage and low voltage windings.

    b. The rating plate shall indicate the transformer is constructed for Extra- Heavy Traction Duty.

10. The transformer enclosure and metallic frame and supports shall be finished in accordance with the Contract documents.

11. A mimic bus shall be provided on the front of transformer enclosure.

12. The transformer shall have vibration isolation pads installed between core and coil assembly and enclosure base structures to prevent the transmission of structure borne vibration.

2.03 RECTIFIER

A. Type and Rating

1. Rectifiers shall be indoor-type, rated 2500 kW at 800 Vdc.

2. The rectifiers shall be natural convection air-cooled, free-standing and metal-enclosed.

3. Each rectifier shall be an integrated twelve-phase double way assembly with 12 pulse rectification as specified in this Section.

4. All rectifiers shall be designed for Extra Heavy Duty Traction Service as defined in this Section.

5. All rectifiers with the same testing shall be identical.

6. The rectifier unit shall be capable of supplying the following 100% continuous rating:

Dc Voltages	800
Dc Amperes	3125
Kilowatts	2500
Dc Insulation	1,000 Volt Class

7. The rectifier unit shall be equipped with dc surge protective devices designed, constructed and tested in accordance with the general requirements of ANSI C62- 11.

B. Silicon Diodes

1. Silicon diodes shall be hermetically sealed and mounted on adequate heat sinks.

2. Diodes shall be rated and tested in accordance with the latest NEMA publication SK-60.

3. Parallel stacks of diodes shall be electrically and geometrically similar and as symmetrical as practical to help balance the normal and surge electrical characteristics of each.

4. At 40°C ambient the rectifier shall be capable of carrying the Extra Heavy Traction loads specified in this Section with one paralleled diode removed from each phase arm without exceeding the safe junction temperature on the active diodes.

5. The rectifier shall be able to withstand a bolted fault on the dc switchgear bus with one parallel diode removed from the phase arm without exceeding the safe diode junction temperature on the active diodes for the time it takes the ac breaker to clear the fault.

6. Each diode shall be capable of withstanding, at its maximum operating temperature during blocking periods without a permanent change in diode characteristic, repetitive voltages having a value 250% of its working peak reverse voltage.

7. Each individual diode shall have a peak reverse voltage rating equal to at least 266% of the applied peak reverse voltage at no load.

8. The rectifier shall be designed to maintain current balance between parallel-connected diodes in each phase. The current for each diode of a parallel-connected stack shall not differ from its proportionate share of the total current by more than plus or minus 10%, between 50% and 150% of the rated capacity. This current balancing scheme shall hold individual diode currents within tolerances with one fuse in each phase arm open. Current balancing shall not be achieved by use of selectively matched diodes.

9. Current limiting fuses with adequate interrupting capacity shall be provided in series with each diode complete with a convenient visual fuse failure indication. Blowing of one fuse in each phase arm shall not reduce overload capacity, nor reduce short-circuit capability.

10. Fuses shall be sized to the diode current rating and shall not open or fail on any external dc fault or rated overload condition. Only the fuse connected to a failed (shorted) diode shall open. No other rectifier diodes or fuses shall fail or be damaged when one diode fails. Any special tools to remove or install the diodes and/or diode fuses and/or hardware shall be furnished with each rectifier.

C. Heating and Cooling System

1. Auxiliary heating will be by a thermostatically-controlled space heater within the substation. Heaters mounted within the rectifier enclosure are not necessary.

2. The rectifier shall be natural convection air-cooled. Circulation of ambient air shall do all necessary cooling at the Extra Heavy Traction loading specified. Heat transfer surfaces and characteristics shall be designed for easy cleaning and to minimize accumulations of dust and other contaminants expected in the operating environment. Cooling ducts shall not be used.

3. In accordance with 2.02, voltages other than 125 Vdc control power are not permitted within the enclosure.

D. Rectifier shall contain a mimic bus furnished on the front panel doors.

2.04 INTERPHASE TRANSFORMER

A. Provide an interphase transformer in coordination with transformer-rectifier unit to meet the specified voltage regulation and maximize efficiency, under the service conditions of VTA.

B. Design and test in accordance with IEEE 1653.2.

C. Mount the interphase transformer on elastomeric pads and enclosed in a non-metallic enclosure designed to damper audible noise.

2.05 PROTECTIVE DEVICES AND RELAYS

A. All protection furnished shall be coordinated to prevent false tripping or malfunction.

B. An insulating dust cover shall be supplied for each internally-mounted device or the chamber that accommodates these devices.

C. All relays and protective devices and their connections shall be mounted within a separate barriered compartment in compliance with ANSI C37.20.3 within the rectifier and transformer enclosure such that the devices are readily accessible without disassembling interior portions of the rectifier assembly. All control wiring shall be contained within the cubicle and shall be isolated from and not intermixed with 800 Vdc power wiring.

D. The following protective devices shall be provided, and all contacts on these devices shall be electrically separated:

1. AC Surge Arrester (ANSI device 199):

    a. Provide AC surge arresters on the rectifier-transformer primary side.

    b. Provide a separate compartment for AC surge arresters within transformer enclosure.

    c. Compartment shall be rigid steel, self-supporting and self-contained, electrically welded or bolted.

2. DC surge arrester (ANSI device 199):

    a. Rectifier unit shall be equipped with DC surge arresters.

    b. The arresters shall limit the reverse voltage across rectifier silicon diodes to a value less than 75 percent of the peak-reverse-voltage rating of the diode by limiting the rise of the transient on the positive to negative bus.

c. Ensure that arresters will fail in a safe manner without damage to equipment and will self-extinguish. Install in separate enclosure if necessary.

3. A factory set, 2-stage rectifier over-temperature device (Device 126/126TH), which will detect first an abnormal rise in diode heat sink or diode temperature and initiate local and remote annunciation. The setpoint for the alarm shall be set during the factory systems test to the level recorded during the two-hour 150% heat run. An additional rise in heat sink temperature will trip and lock out the ac breaker, open the main dc breaker and shall annunciate locally and remotely. The devices shall be isolated from the bus voltage.

4. Door position contacts (Device 33R) located on the rectifier enclosure doors shall trip and lockout the ac breaker, main dc breaker, and feeder breakers, and annunciate an opening of a door. Separate control compartments do not require Device 33.

5. Low Resistance Frame fault protection (Device 164/164G) as described in Section 34 21 20.

6. Rectifier diode failure supervision (Device 198A/198B) shall be provided with two-stage, electrically independent contacts, which close from the failure of diodes for alarm (first stage) and tripping (second stage).

   a. First stage, diode failure supervision (Device 198A) shall initiate an alarm on the HMI and SCADA when one diode fails.

   b. The failure of two diodes shall initiate the second stage. Device 198B shall trigger an alarm on the HMI and SCADA, and shall also trip and lockout the ac breaker and the main dc circuit breaker.

7. A transformer thermal relay (Device 49T/49TH) shall be provided with two-stage, electrically independent contacts which close on rising temperatures for alarm (first stage) and tripping (second stage).

   a. First stage of temperature supervision, 49T, shall initiate an alarm on the transformer temperature monitor, and the HMI, and SCADA.

   b. The first stage shall initially be set at the temperature reached during the 2-hour heat run at 150 percent rated output, and annunciate when this temperature is reached.

   c. Second stage, 49TH, shall initiate an alarm on the transformer temperature monitor, the HMI, and SCADA, and shall also trip and lockout the ac breaker and the main dc circuit breaker.

d. Set Points

1) Temperature set points, T1 and T2, shall be field adjustable.

2) Set points shall be factory-preset value when transformer is provided, as recommended by the manufacturer and approved by VTA.

2.06 RECTIFIER COMPARTMENT

A. Each rectifier shall be an operative assembly, consisting of silicon diodes, internal buses, terminals for connection to external power and control wiring or buses, shunts, base or bleeder load resistors, protective devices, control wiring, terminal blocks, compartments, cubicles, and all other necessary accessories.

B. The rectifier assembly shall be mounted in a metal enclosed switchgear section or compartment. The switchgear section shall be indoor, ventilated, metal enclosed structure, with barriers, compartments, and hinged doors.

C. The compartment shall be assembled with a rigid self-supporting structural steel framework and shall have all principal structural members electrically welded or bolted together.

D. The compartment shall be constructed of minimum No. 11 gauge steel.

E. The access doors or panels shall be minimum 11 gauge sheet metal.

F. Openings and mounting holes for front-mounted indicating and control devices shall be installed without damaging the exposed finished surfaces.

G. The enclosure shall be the same color as remaining substation enclosures. Refer to Contract Documents for painting requirements.

H. The enclosures shall be fabricated with structural members of sufficient strength to support the buswork under short circuit conditions.

I. Convenient access doors on the front and rear of the section shall be provided for all normal maintenance and inspection. Each door shall be equipped with a heavy duty latch to hold the door fully and securely closed. Door stops shall be provided to hold the door in the open position. Hinges shall be a stainless steel heavy-duty type.

J. Lifting eyes shall be provided for lifting the rectifier unit from the top. Provision for lifting from the bottom shall also be provided. The completed package shall be capable of being skidded or rolled any direction. Jacking lugs shall be provided at each base corner. Provisions shall be made to bolt the base to the floor in a manner which will meet the seismic withstand and electrical insulating requirements indicated.

2.07 BUS AND CONNECTIONS

A. Rectifier buses shall be made of rigid, high conductivity, electrical grade copper. Buses shall be suitably braced between each other and to the enclosure, with high-strength, non- tracking porcelain insulators.

B. Buses shall be braced to safely withstand the available short-circuit current without damage to the bus or the switchgear.

C. Aluminum/copper bus connections shall be welded, except where disconnection is required for maintenance in which case connection shall be bolted. All bus connections shall be bolted using a minimum of four (4) bolts per joint. Wherever bolted together, the mating surfaces of copper buses shall be silver-plated. All bolted connections shall be made with Belleville washers.

D. Buses shall extend through the compartment walls to rear bus compartment and connected to the dc switchgear where applicable.

E. The rectifier section shall be designed as an integral part of the dc switchgear, and shall be insulated from the ac and dc switchgear, substation grounds, or other enclosures.

F. Metal barriers shall be electrically bonded to the frame between dc positive and negative buses and terminal connections within the rectifier.

G. Provide interior lighting with an external switch as required below:

1. General: Ceiling and side mounted, LED strip luminaire with clear, prismatic diffuser, complying with UL 8750.

2. Minimum illuminance: 30 foot-candles at 1.5 feet

3. Correlated Color Temperature: 5000-6000 K

4. Size: 30 centimeters or 12 inches long with 12 LEDs.

5. MBF: 50,000 hours

2.08 NAMEPLATE

A. Each rectifier shall be provided with a corrosion resistant metal nameplate containing the following information at a minimum:

1. Name of Manufacturer
2. Descriptive Name
3. Type Designation
4. Serial Number(s)
5. Output Rated Power
6. Output Rated Voltage
7. Output Rated Current
8. Overload Currents – Magnitude and Duration
9. Weight
10. Schematic Diagram Number

2.09 INTERNAL COMPONENTS

A. All internal wires shall be rated at 1 kV minimum unless otherwise specified.

B. 800 V minimum fuses shall be indicating type of the drawout design.

C. Control devices and relays shall be mounted in a separate compartment.

D. No 800 V devices shall be mounted in control compartment.

E. 125Vdc overcurrent control shall be via two (2) pole din rail mounted circuit breakers.

PART 3 - EXECUTION

3.01 MANUFACTURE

The rectifier-transformer unit shall be manufactured in accordance with the reference ANSI standards, and Section 34 21 01 – Traction Power Basic Electrical Materials and Methods.

3.02 INSTALLATION

The rectifier-transformer unit shall be installed in accordance with Section 34 21 16, – Traction Power Substations.

END OF SECTION 34 21 23

SECTION 34 21 26

PAD-MOUNTED DC DISCONNECT SWITCHES

PART 1 - GENERAL

1.01 SUMMARY

A. Work of this Section covers the requirements for designing, manufacturing, furnishing, delivering, unloading, setting in-place, and complete installation of pad-mounted manual DC disconnect switch assemblies. The equipment shall be delivered as completely assembled and tested units, ready for installation and connection to external wiring and power cables at TPSS #33 and TPSS #34.

1.02 REFERENCED STANDARDS

A. Provisions of the latest edition of the following standards apply to this Work unless a specific date is stated in this Specification:

1. American National Standards Institute (ANSI)
2. ANSI C37.34 Test Code for High-Voltage Air Switches
3. ASTM International (ASTM)
4. ASTM B187 Copper Bus Bar, Rod and Shapes
5. Institute of Electrical and Electronics Engineers (IEEE)
   a) IEEE C37.34 Standard Test Code for High-Voltage Air Switches
6. National Electrical Manufactures Association (NEMA)
7. NEMA 250 Enclosures for Electrical Equipment (1,000 Volts Maximum)
8. NEMA ICS 1 Industrial Controls and Systems: General Requirements
9. NEMA ICS 2 Industrial Control and Systems Controllers, Contactors and Overload Relays Rated 600 Volts

1.03 SUBMITTALS

A. Submit the items described below within 120 Days of NTP.

B. Complete manufacturer’s descriptions, catalog data, and information including materials and model numbers.

C. Manufacturer's general and detail arrangement drawings for switches and enclosures.

D. Provide all dimensions including enclosure.

E. Provide installation instructions.

F. Interlocking control schematics

G. Submit test procedures and test reports in accordance with Section 34 21 63, Testing and Commissioning.

H. Design Tests: Submit design procedures and reports for each type of switch, in accordance with Section 34 21 63

I. Production Tests: Submit production test procedures and reports for each switch, in accordance with Section 34 21 63.

J. Operation and Maintenance Data: Submit Operation and Maintenance Data, including the following requirements:

K. Description of the switch and its components

L. Manufacturers' operating and maintenance instructions, parts list, illustrations and diagram for components.

M. Recommended list of spare parts.

N. Wiring diagram

1.04 MEASUREMENT AND PAYMENT

A. Measurement: Furnish & Install Pad Mounted DC Disconnect Switch Assemblies shall be measured by the each.

B. Payment: The contract price paid per each shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Furnish & Install Pad Mounted DC Disconnect Switch Assemblies complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed thereafter.

1. Payment will be made at the Contract unit price under:

a.	TPSS #33 - Furnish and install of four (4) DC feeder disconnect and two (2) bypass disconnect switches	EA
b.	TPSS #34 - Furnish and install of four (4) DC feeder disconnect and five (5) bypass disconnect switches	EA

1.05 QUALITY ASSURANCE / QUALITY CONTROL

A. Refer to General Conditions GC-47, Quality Assurance Program for general requirements and procedures.

B. Dc Disconnect Switches shall be UL labeled or shall be furnished with a Field Evaluations label in accordance with Section 34 21 01, Traction Power Basic Electrical Materials and Methods.

C. Dc Disconnect Switches shall have 5 years successful operation in service at a transit application operating at 800 Vdc.

D. Approved Manufacturers:

E. Siemens, MAC Products, or VTA approved equal.

F. Alternative suppliers must obtain approval from VTA at least 14 days prior to submitting bid.

PART 2 - PRODUCTS

2.01 SWITCH TYPE

A. Enclosed, single-pole single-throw air break switch.

B. Manual operator.

C. Provide enclosures as indicated.

D. Comply with applicable requirements in ANSI C37.34, ASTM B187, NEMA 250, ICS 1, and ICS 2.

2.02 SWITCH RATINGS

A. Voltage: 1000 Vdc maximum

B. Insulation Level: Dry 1 minute power frequency 3.7kV rms (energized parts to ground and gap between positive and negative parts).

C. Continuous Current Ratings: As indicated in Contract Drawings without the switch contact temperature rise exceeding 50 degrees C above a maximum ambient temperature of 40 degrees C.

2.03 SWITCH CONTACTS

A. Contacts: Self-aligning, wear compensating, with initial wiping action.

B. Contact Surfaces: Silver plated copper.

C. Other Current-Carrying Parts: High conductivity copper or copper alloy.

D. Hinge and Jaw Contacts: Bolted pressure type with non-ferrous or stainless steel self- clamping mechanism, or other approved high-pressure type contact arrangement.

2.04 SWITCH ASSEMBLY

A. Operating Handle: Insulated, manual, externally mounted on the front or side.

1. Padlockable in the fully open or closed switch positions.

2. Provide one padlock for each switch operating handle. VTA to provide padlock keying requirements.

B. Switch Assembly Insulation

1. Noncombustible, nonhygroscopic, and tracking resistant.

2. Mechanical Strength: Match the stresses imposed by the rated momentary current.

C. Switch assemblies to be factory assembled and precision aligned on base material and not be susceptible to nor subjected to distortion, during box or field installation.

2.05 INTERLOCKING

E. Each disconnect switch shall be provided with an electro-mechanical interlock actuated by a voltage relay connected to the line-side and load-side of the disconnect switch, to prevent operation when the load side of the disconnect switch is energized.

F. In addition to the electro-mechanical interlocks specified, each feeder disconnect switch shall be provided with an interlock to prevent switch opening if the associated circuit breaker is closed. This interlock shall be achieved directly through and auxiliarycontact from the DC circuit breaker and may be integrated with the electro-mechanical interlock specified above.

G. The control wiring and the connection to the negative shall be routed through separate conduits to ensure isolation from the positive feeders, and the relays for the electro-mechanical interlock specified above shall be located in a convenient padlockable separate compartment integrated with the switch assembly. Access to this compartment shall be independent of and without exposing any components of the three switch compartments.

2.06 VOLTAGE SENSING RELAYS

A. Two voltage sensing relays shall be provided in each switch assembly sensing the output voltage to the OCS. The relay shall pick-up at a minimum voltage of 300 Vdc and shall maintain the "OCES Energized" status until the voltage level drops to below 80% to 90% of the pick-up level, subject to approval by VTA.

B. Each relay output shall consist of three form-C dry contacts for local and remote indication of the status of the monitored OCS section, as shown on ContractDrawings.

C. Relay shall be rated for a minim operating level of 125 Vdc.

D. The relay shall be of substantially similar design or design derivative of a relay proven in service in traction power substations for at least 3 years. Relays shall conform to the applicable sections of ANSI C37.1.

2.07 CABLE TERMINATION

A. Provide line and load side switch terminals with bus to accommodate the number and size of dc power cables, as indicated.

Bus: Silver-plated copper complying with ASTM B187

Cable Lugs: Provide proper size and quantity of NEMA cable lugs.

2.08 SWITCH AUXILIARY CONTACTS

A. The switch shall be equipped with 4 form-C auxiliary contact for remote status indication: 2 for "switch-open" status, and 2 for "switch-closed" status. The set of form- C auxiliary contact for switch open indication shall change status when the operating handle is about 15 degrees away from the "switch-open" position; the set of form-C auxiliary contacts for switch closed indication shall change status when the operating handle is about 15 degrees away from the "switch-closed" position. Auxiliary contacts shall be rated for 10 A at 125 V (dc), and shall be fully enclosed and wired to a suitable terminal block within the overall enclosure for a SCADA wiring termination. Suitable knockouts shall be provided in the enclosure for conduit attachment were required.

2.09 SWITCH ENCLOSURE

A. Type: Suitable for wall mounting, as indicated, NEMA 250, Type 4.

B. Size: As indicated on the drawing

C. Material: Molded fiberglass-reinforced polyester having 1/4-inch minimum thickness and 30 to 70 glass to resin ratio.

1. Minimum Tensile Strength: 1,500 psi
2. Maximum Water Absorption: 0.05 percent in 24 hours at 70 degrees C
3. Fire-retardant
4. Exterior Surface: Clear polyester get protective coat.
5. Polyester Color: ANSI 61 Grey

D. Door

1. Gasketed.
2. Hinges: Continuous steel.
3. Swing Opening: 120 degrees minimum with door stop.
4. Latch: Three-point stainless steel.
5. Handle: Metallic, padlockable.
6. Padlock: Heavy duty. Provide one for each switch door handle. Key as determined by VTA.

E. Viewing Window: Shatterproof, as required to permit observation of switch position from outside the enclosure with door closed.

F. Conduit Hubs: Provide as required for entry of power and control cable.

G. Exterior Mounting Tabs: Suitable to hold switch and box with two tabs removed.

H. Bonding and Grounding: Make non-current-carrying exposed metallic parts electrically continuous with minimum No. 10 AWG flexible copper conductor connected to a tinned copper terminal block. Connect terminal to a local ground.

I. Signage:

1. Permanent, corrosion resistant, with minimum 2-inch high letter size.
2. Mount with stainless steel screws.
3. Warning Sign: “DO NOT OPERATE UNDER LOAD” mounted ondoor.
4. Switch Position: “OPEN” and “CLOSED” mounted by operating handle to show positions of switch contacts.

J. Insulate mounting hardware protruding through enclosure wall.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install switches in accordance with the approved manufacturer’s instructions.

B. Coordinate installation with design of disconnect switch supporting hardware, feeder wire installation and routing and ensure designs are fully integrated with the installed attachments.

C. Provide supports on line and load side cables to prevent stress on switch cable connections.

END OF SECTION 34 21 26

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SECTION 34 21 27

TRACTION POWER GROUNDING AND BONDING

PART 1 - GENERAL

1.01 SUMMARY

This Section describes the Work of providing ground cables and wires to all equipment and material which is required to be grounded by the National Electrical Code and Contract Documents.

This Section also covers pigtails for connections to equipment in the Traction Power Substation as shown on the Contract Drawings.

1.02 REFERENCE STANDARDS

Organization	Number	Title
ASTM	B 3	Specifications for Soft or Annealed Copper Wire
ASTM	B 187	Copper Bus Bar, Rod and Shapes
NFPA	70	National Electrical Code (NEC)

1.03 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of Section 01 33 00.

B. Submit Product Data on the following items:
   1. Ground conductors
   2. Connectors, bushings and fittings
   3. Exothermic welding process, materials and molds

C. Submit Test Reports in accordance with Section 34 21 63, Testing and Commissioning.

D. Submit a sample of each type of mechanical and compression connector proposed, along with a description of its intended use.

1.04 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed thereafter.

1.05 QUALITY CONTROL

A. Refer to General Conditions GC-47, Quality Assurance Program for general requirements and procedures.

1.06 QUALITY ASSURANCE

A. All products furnished under this Section shall conform to referenced ASTM and UL standards.

B. All grounding shall comply with the requirements of NFPA 70 (NEC).

1.07 PROJECT RECORD DOCUMENTS

A. Project Record Documents (As-Built Drawings) shall be provided in accordance with the Contract Documents, except as modified herein.

B. Provide Project Documents of all grounding systems as actually installed under this Contract.

PART 2 - PRODUCTS

2.01 BASIC GROUNDING MATERIALS

A. Bare conductors shall be class B stranded, annealed copper, and conform to ASTM B3. Provide the size shown on the Drawings. Aluminum conductors are not permitted.

B. Single insulated conductors shall conform to the requirements of 34 21 28 – Traction Power Wire and Cable, for 600 volt insulated conductors. Provide green insulation for conductor sizes of 2 AWG and smaller and black insulation with ends green taped for larger sizes.

C. Bus bar shall conform to ASTM B187, 98 percent conductivity copper, size as shown on the Drawings.

D. Lugs shall be suitable for attaching a ground conductor to equipment or metallic surfaces, and shall be NEMA 2 hole, compression type, tin or silver plated copper, hydraulic tool applied, as manufactured by Thomas and Betts, Burndy, or approved equal.

E. Bolts and miscellaneous hardware for grounding shall be silicon bronze.

F. Jumpers shall be tin-plated copper, braided, and flexible.

G. Compression connectors for grounding in above ground dry locations, shall be Burndy YG series, or approved equal.

H. Mechanical connectors for grounding above ground in dry locations, and for attachment to equipment, boxes, or finished electrical products, shall be Burndy GB, GC, or approved equal.

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, which are placed in the mold along with the conductors to be welded. Ignition of the powder shall produce molten copper that welds the conductors to each other and to a surface, as the case may be. Exothermic materials and products shall be "CADWELD" as manufactured by ERICO Products, Inc., Thermoweld, or approved equal.

PART 3 - EXECUTION

3.01 GENERAL GROUNDING REQUIREMENTS

A. Provide all grounding as specified and shown on the Drawings.

B. Unless otherwise indicated, all underground grounding connections shall be by exothermic welding. Unless otherwise indicated, all connections located outdoors, or above ground in damp, or wet locations shall be by exothermic welding. Do not use compression or mechanical connections underground. Grounding connections shall not be soldered.

C. Exothermically weld embedded ground cables and fittings to concrete reinforcing steel and secure with steel tie wires to prevent displacement during concrete placement.

D. Grounding conductors shall be protected from physical and environmental damage. Wherever possible, and where shown, grounding electrode and bonding conductors shall be enclosed in a non-metallic raceway. Exposed conductors that must extend from a concrete surface shall be located as close as possible to a corner. Where conductors are required to be 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.

E. 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.

F. Service grounds and grounding or bonding of electrical service equipment shall be with continuous unspliced grounding conductor.

3.02 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, and as otherwise shown.

B. Ground conductors shall be provided in non-metallic raceway systems in accordance with the NEC and as indicated on the Drawings.

3.03 EXOTHERMIC WELDING

A. The surface to be welded shall be clean and dry. Wire brush or file the point of contact to a clean bare metal surface.

B. Use welding cartridges and molds for the type of weld shown on the Drawings, and perform welding in accordance with the manufacturer's recommendations. Worn or damaged molds shall not be used.

C. After welds have been completed and cooled, brush slag from the weld area and thoroughly clean the joint.

D. Where exothermic grounding connections made between copper wire and steel surfaces are direct buried, coat the connection with a coal tar epoxy coating per specification before backfilling. Also, coat the entire area of the steel surface disturbed by the exothermic welding.

E. Unless otherwise indicated, use exothermic welding for all underground cable to cable splices, tees, crosses, etc., and all cable connections to ground rods, ground rod splices, cable to steel and cast iron, and underground cable lug terminations.

F. Use exothermic welding for grounding connections to rail, reinforcement steel, or structural steel.

G. Test all welds by striking with a two-pound steel hammer. Replace any defective welds. Replace any welds and molds as directed by VTA.

H. Where exothermic welds are made to a galvanized surface, remove the galvanizing using a grinding wheel to expose a clean surface. After welding, touch up the steel surface with zinc rich primer.

3.04 GROUNDING CONNECTIONS TO ELECTRICAL EQUIPMENT

A. Bond boxes to the raceway or conduit system with a copper jumper solidly bolted to the box sized per NFPA 70.

B. Ground connections to cabinets or equipment frames in dry location shall be made utilizing a compression type terminal lug. Lug shall be attached to item being grounded with stainless steel or silicon bronze bolting hardware.

C. Ground metallic raceways, boxes, cabinets, exposed expansion joints, lighting fixtures, motors, transformers and receptacles. Provide grounding bushings or compression connectors attached with machine screws for bonding.

3.05 SUBSTATION GROUNDING

A. The existing substation ground mat resistance shall be retested. Additional copper cables and ground rods shall be installed as required to maintain the minimum ground resistance of 5 ohms.

END OF SECTION 34 21 27

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SECTION 34 21 28
TRACTION POWER WIRE AND CABLE

PART 1 - GENERAL

1.01 SUMMARY

A. This Section describes the Work of furnishing and installing all wire and cable for use in the traction power system. The wire and cable include:

1. 600 V rated wire and cable and associated splices and terminations.

2. Other low voltage wire and cable, splices and terminations.

3. 2 kV rated insulated cable and associated terminations, connectors, splices and other accessories for the positive and negative 800 Vdc traction power circuits.

4. 25KV power cable splices and terminations

1.02 REFERENCE STANDARDS

Organization	Number	Title
AEIC	CS8	Specifications for Extruded Dielectric Shielded Power Cables 5-46 kV, Associations of Edison Illuminating Companies
ASTM	B-8	Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM	B-33	Standard Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes
ASTM	B-189	Lead-Coated and Lead-Alloy-Coated Soft Copper Wire for Electrical Purposes
ASTM	B-496	Specification for Compact Round Concentric-Lay- Stranded Copper Conductors
ASTM	D-747	Standard Test Method for Apparent Bending Modules of Plastics by Means of a Cantilever Beam

ICEA	S-73-532	Control, Thermocouple Extension, and Instrumentation Cables
ICEA	T-29-520	Vertical Cable Tray Flame Test @ 210,000 Btu
ICEA	S-93-639	5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electrical Energy
ICEA	S-95-658	Non-shielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy
ICEA	S-96-659	Non-shielded Power Cable Rated 2001-5000 Volts
NFPA	70	National Electrical Code
ANSI/IEEE	48	Test Procedures and Requirements for Alternating Current Cable Terminations 2.5 kV through 765 kV
ANSI/IEEE	404	Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500 000 V
ANSI/IEEE	1202	Flame Testing of Cables for Use in Cable Tray in Industrial and Commercial Occupancies
UL	1072	Standard for Medium-Voltage Power Cables
UL	1277	Electrical Power and Control Tray Cables with Optional Optical-Fiber Member
UL	1581	Reference Standard for Electrical Wires, Cables, and Flexible Cords

1.03 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of Section 01 33 00, except as modified herein.

B. Submit Product Data on the following items:

1. Single-conductor wire and cable
2. Multi-conductor wire and cable
3. Splicing and termination materials

4. Cable pulling equipment
5. Mounting hardware
6. Cable Tags

C. Product information for each type and size of wire and cable shall include the following:

1. Manufacturer of the wire and cable
2. Number and size of strands composing each conductor
3. Conductor insulation composition and thickness
4. Average overall diameter of finished wire and cable
5. Single-conductor ampacity at 30°C ambient for no more than 3 current-carrying conductors in steel raceway
6. Storage instructions

D. Certified copies of manufacturer's test reports for the cables, terminations, connection and splices. The standard dielectric withstand tests shall be performed on each reel of 2 kV cable prior to shipment. A certified copy of the test report shall be furnished to VTA prior to shipment. Each reel of cable shall be newly manufactured (no more than 12 months old), and shall bear a tag containing name of manufacturer, NEC designation, and year of manufacture.

1.04 MEASUREMENT AND PAYMENT

A. Except for 2KV Power Cable, full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed thereafter.

B. Measurement: 2KV Power Cable shall be measured by the linear foot.

C. Payment: The contract price paid per linear foot for 2KV Power Cable shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing 2KV Power Cable complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefore.

1. Payment will be made at the Contract unit price under:

a.	1/C-500 KCMIL 2KV power cable installed and terminated	LF

1.05 QUALITY CONTROL

Refer to General Conditions GC-47, Quality Assurance Program for general requirements and procedures.

1.06 QUALITY ASSURANCE

A. Qualifications

1. All wire and cable manufacturers must be approved by VTA. The approval will be based on the qualification requirements indicated herein. The Contractor shall provide all data required for VTA's evaluation.

2. Qualifications shall be based on the following criteria:

   a. Past Performance and Experience: The cable manufacturer shall demonstrate previous successful experience in supplying wire and cable specified herein. A list of such installations shall be provided for each cable manufacturer to be considered. Cables of the same ratings and materials required for this contract shall have been produced by the manufacturer and shall have at least five years of successful operation in rail transit service.

   b. Quality Assurance Program: The cable manufacturer shall have in place or shall implement an effective quality assurance program adhering to the requirements of ISO 9001 to ensure purchase control performance. VTA reserves the right to audit the manufacturer's facilities for conformance to the contract. This may include, but is not limited to first article inspections, source inspections, and on-site surveys. The manufacturer's quality assurance program shall include the necessary formal assurance requirements to ensure that cable failure cannot be attributed to actions or lack of actions by the manufacturer.

   c. Technical data: Provide full technical data that demonstrates compliance with the requirements of these Specifications for each specified cable type to be furnished.

B. Sample Specimens

1. The Contractor shall, if requested by VTA, furnish sample specimens in four (4) foot lengths similar to that which the manufacturer proposes to furnish for each type cable specified herein. The sample specimens shall remain the property of VTA.

C. After Selection

1. The Contractor shall monitor the manufacturer of the wire and cable to assure that the approved Quality Assurance Program is being closely adhered to and that the wire and cable is being manufactured in accordance with these Specifications and the approved submittals.

2. Each finished wire and cable shall be traceable to the test date on file for each step in its manufacturing process.

3. Inspection

   a. VTA, or its authorized representative, shall have the right to make such inspection and tests as necessary to determine if the cable meets the requirements of these Specifications. The inspector for VTA shall have the right to reject cable that is defective in any respect.

   b. VTA shall be given fifteen (15) days advance notice of the date the cable will be ready for final testing so that VTA may witness the tests.

   c. Certified electrical and physical test reports shall be furnished for the finished cables no later than the time of shipment. Each test document shall, in addition to the test results, indicate the date the tests were performed and the signature of the manufacturer's authorized representative.

   d. VTA reserves the right to conduct additional tests in order to verify that the cable is manufactured in accordance with the requirements of these Specifications.

PART 2 - PRODUCTS

2.01 600 VOLT SINGLE CONDUCTOR WIRE AND CABLE

All conductors shall be stranded copper, unless otherwise indicated.

Minimum size: No. 12 AWG, unless otherwise indicated.

Conductor insulation shall be rated 90°C wet or dry.

Where wire and cable are completely contained in raceway and boxes in dry locations, type XHHW is approved for use, unless otherwise indicated.

All wire and cable installed in underground raceways or wet locations shall have type XHHW-2 insulation unless otherwise indicated.

2.02 600 VOLT SPLICES

In dry locations use pre-insulated spring-wire connectors for No. 10 AWG conductors and smaller. Splices shall be 3M "Scotch-Lok", Ideal "Wing-Nut", Burndy, or approved equal.

Splices No.8 and larger shall use tin or silver plated copper compression sleeves as manufactured by Thomas and Betts, Burndy, or approved equal.

Underground splices, shall be made watertight with epoxy resin type splicing kits, "Scotchcast" or approved equal.

Insulation for above-ground splices and taps shall be heat shrink polyolefin, rated for 600 volts and 90°C, and watertight. Manufacturer shall be Thomas and Betts, Raychem, or approved equal.

2.03 600 VOLT TERMINATIONS

In dry locations, use pre-insulated solderless type of termination for No. 10 AWG and smaller where terminating on screw terminals. Use Thomas and Betts "Stakon" ring tongue, Panduit, or approved equal.

Terminations No. 8 and larger shall use tin or silver plated copper compression type lugs with NEMA bolt hole patterns as manufactured by Thomas and Betts, Burndy, or approved equal. Aluminum or aluminum alloy terminals shall not be used except for aluminum aerial cable.

Underground terminations shall be made watertight with epoxy resin type splicing kits, "Scotchcast", or approved equal.

Insulation for above-ground terminations shall be heat shrink polyolefin, rated for 600 volts, and weatherproof. Insulation shall be by Thomas and Betts, Raychem, or approved equal.

Terminations in circuit breaker lugs, or where factory supplied lugs are provided per NEMA standards, shall be in accordance with manufacturer's recommendations.

2.04 600 VOLT MULTI-CONDUCTOR TYPE TC CONTROL CABLE

The cable shall be 600 volt multi-conductor UL listed type TC for installation in conduit or cable tray use, at 90°C dry and 75°C wet applications. The cable shall be suitable for use on power and control circuits outdoors or indoors installed in cable trays or raceways.

The individual conductors shall be coated copper per ASTM B-33 or B-189, and Class B stranded per ASTM B-8.

The conductor insulation shall be heat, moisture, flame, and chemical resistant ethylene- propylene insulating compound, which meets or exceeds requirements of UL 1581 and ICEA S-95-658 Type II insulation. The conductor insulation shall be color coded per ICEA S-95-658 method 4. Conductors which rely upon a nylon or similar sheath for their ratings are not acceptable.

The conductors shall be cabled in accordance with UL 1277 using fillers, as required, with a cable tape overall. The overall jacket shall be a vulcanized chloro-sulfonated polyethylene (hypalon) compound and comply with the requirements of UL 1277 and exceed the requirements of UL 1581. The cable shall pass the vertical tray flame test requirements of UL 1277 for type TC power and control Tray Cable at 70,000 Btu/Hr and the ICEA T-29-520 210,000 Btu/Hr test.

The minimum conductor size shall be No. 14 AWG, unless specifically approved otherwise by VTA.

2.05 600 VOLT MULTI-CONDUCTOR TYPE P-OS OR SP-OS TYPE TC INSTRUMENTATION CABLE

The cable shall be 600 volt multi-conductor UL listed type TC that meets UL 1277 and rated for 90 degrees C dry and for 75 degrees C wet applications. The cable shall be suitable for use on instrumentation control circuits outdoors or indoors when installed in cable trays or raceways.

The individual conductors shall be stranded copper, twisted into groups of pairs or triads, with an integral aluminum polyester shield and coated shielded copper drain wire.

Type P-OS (pairs with overall shield) and type SP-OS (shielded pairs with overall shield) cable shall be used only with specific approval of VTA.

2.06 600 VOLT WIRE TIES AND CLAMPS

Wire ties, clamps, and anchors shall be nylon formulated for resistance to ozone and ultraviolet light, rated for outdoor service, and shall last the life of the traction electrification system. Wire ties shall be installed with tools with automatic tensioning devices, as supplied by the wire tie manufacturer. Wire ties shall be installed with sufficient tension to restrain the wiring without indenting the wire insulation.

If used, wire tie anchors shall be rigidly fastened to the equipment or a rigid structure. Adhesive-based wire tie anchors are not permitted.

Wire tie width shall be selected for intended tensile load, and sufficient bearing to prevent insulation indentation and damage.

Wire clamps shall be either nylon or stainless steel covered with neoprene or silicon rubber similar to those manufactured by Adel, and suitable for interior or exterior applications. Wire clamps shall be sized for each harness such that no less than 90% of the harness circumference is securely clamped. Clamps shall be fastened with bolts and elastic stop nuts.

2.07 2KV VOLT MULTI-CONDUCTOR TYPE TC CONTROL CABLE

The cable shall be 2000 volt multi-conductor UL listed type TC for installation in conduit or cable tray use, at 90°C dry and 75°C wet applications. The cable shall be suitable for use on power and control circuits outdoors or indoors installed in cable trays or raceways.

The individual conductors shall be coated copper per ASTM B-33 or B-189, and Class B stranded per ASTM B-8.

The conductor insulation shall be heat, moisture, flame, and chemical resistant ethylene- propylene insulating compound, which meets or exceeds requirements of UL 1581 and ICEA S-95-658 Type II insulation. The conductor insulation shall be color coded per ICEA S-95-658 method 4. Conductors which rely upon a nylon or similar sheath for their ratings are not acceptable.

The conductors shall be cabled in accordance with UL 1277 using fillers, as required, with a cable tape overall. The overall jacket shall be a vulcanized chlorosulfonated polyethylene (hypalon) compound and comply with the requirements of UL 1277 and exceed the requirements of UL 1581. The cable shall pass the vertical tray flame test requirements of UL 1277 for type TC power and control Tray Cable at 70,000 Btu/Hr and the ICEA T-29-520 210,000 Btu/Hr test.

The minimum conductor size shall be No. 14 AWG, unless specifically approved otherwise by VTA.

2.08 2 KV POWER CABLE

A. Size and application:

1. Dc positive feeders and dc negative return cables shall be 500 kcmil.

B. Cables shall be insulated conductors with the following characteristics:

1. Description: Insulated feeder cable shall be 2,000 volt single conductor type, UL listed as RHH-2 or RHW-2 for installation in conduit or cable tray, at 90 degrees C in a dry or wet environment.

2. Conductors: The conductors shall be stranded copper, complying with ASTM B8 and B33, or B-189.

3. The conductor insulation shall be heat, moisture, flame and chemical resistant ethylene-propylene rubber (EPR) that meets or exceeds the requirements of ASTM D2802, NEMA WC-8, and ICEA S-68-516.

4. The cable shall pass the vertical tray flame test requirements of UL 1581 and IEEE 383 and the ICEA T-29-520 210,000 Btu/Hr vertical flame test.

5. Shielding: The cable shall not be shielded.

6. Cable Identification: The following information shall be printed on jacket, using contrasting color ink, at not more than 2 feet intervals:

   a. Manufacturer's name

   b. Conductor size

   c. Voltage rating

   d. Insulation type and thickness

   e. Jacket type and thickness

   f. Year of manufacture

C. Terminations in circuit breaker lugs shall be in accordance with manufacturer's recommendations.

D. Solderless compression terminals shall be high conductivity, corrosion resistant type, as manufactured by Thomas Betts, Burndy, or approved equal. Compression lugs shall be NEMA 2-hole type.

E. All terminals shall use tin or silver-plated copper type connections. All bolts shall be silicon bronze. Aluminum or aluminum alloy terminals shall not be used.

F. Dc feeder cable splices shall conform to the following requirements:

1. Splices shall be either "tee" or "crab" type connector assemblies. The assemblies include provisions for terminating conductors by means of hydraulic applied compression type NEMA 2 hole lugs.

2. Shrinkable watertight boots or similar provisions shall be provided for each cable termination at the splice connector assembly.

3. Splices shall be submersible watertight (rated NEMA 6P) and suitable for installation in underground pull boxes subject to flooding.

4. Splices shall be acid and alkali resistant.

5. Splices shall be insulated for 2,000 volt dc minimum. Splices shall be sized to carry the full rated current of the connected cables.

6. Splices of the type provided shall have at least five years of successful installation on rail transit projects.

2.09 TERMINATIONS AND SPLICES FOR 2 KV POWER CABLE

A. Power wiring shall be terminated with bolted compression terminals as manufactured by AMP, Thomas & Betts, Burndy, or approved equal and shall be applied using tools and procedures recommended by the terminal manufacturer. The Contractor shall submit the proposed product line for approval. Crimping tools shall be hexagonal jawed mechanical ratcheting types or electric/hydraulic type that insures a complete compression. Electric/hydraulic types shall be used on all splices and terminations for wire size 2 AWG and larger. Double bolted NEMA 2 hole terminals shall be used at all locations where rotation of a single bolted terminal would result in contact or unacceptable clearance with other conductors or the enclosure and for terminations of wire size 2 AWG and larger.

B. Where splices are detailed on the drawings, install the splice as shown and as directed by VTA. All splices shall use components rated for 2 kV comprised of heavy duty heat shrink sleeves, insulating tubing, and environmental sealant. Splices shall be wraparound, heat-shrinkable, completely waterproof, and shall utilize a strip environmental sealant installed per the manufacturer's instructions. Splices shall be manufactured by Ray Chem or approved equal and shall utilize type CRSM wraparound heat shrink sleeves, type BPTM 2 kV insulating tubing, and red strip environmental sealant, as recommended by the manufacturer.

2.10 REELS AND PACKING FOR 2 KV POWER CABLE

The cable shall be furnished on returnable wooden reels. Reels shall be constructed of good material and shall afford proper protection for the cable during shipment and handling.

A watertight seal shall be applied to each end of the cable to prevent the entrance of moisture during transit or out-of-door storage.

2.11 25 KV POWER CABLE SPLICES AND TERMINATIONS

Cable terminations shall be 25 kV class with the following characteristics:

1. Type: Solid polymeric environmentally sealed heat shrink termination

    a. Ac withstand, 1 minute at 65 kV

    b. Dc withstand, 15 minutes at 105 kV

    c. CEV, minimum 21.5 kV for 3pC or less

    d. Impulse withstand, 150 kV crest for 1.2 x 50 microseconds

    e. Continuous Current Rating – Equal or better than the cable rating

    f. Nominal length – 15-1/2 inches

    g. Wet withstand, 60 kV for 10 seconds

    h. Dry withstand, 55 kV for 6 hours

2. The terminations supplied shall be capable of properly terminating a 25 kV class single conductor polymeric insulated cable, sized as shown on the drawings. The terminations shall meet Class I requirements and be design proof tested per IEEE 48-1975, and be capable of passing a testing sequence per IEEE 404-1986. The terminations as specified shall accommodate any common form of cable shielding/construction without the need for special adapters or accessories, and shall accommodate a wide range of cable size. They shall also be capable of being properly installed on out-of-round or out-of-tolerance cable as per relevant ICEA standards, and accommodate commercially available connectors as specified herein.

3. Terminations of single conductor cables shall consist of heat shrinkable stress control and outer non-tracking insulation tubings along with a high relative permittivity stress relief mastic for insulation shield cutback treatment with a heat activated sealant for environmental sealing. Conductors shall be terminated with compression terminals as recommended by the manufacturer, and shall be applied using a hydraulic tool and procedures recommended by the terminal manufacturer.

4. Double bolted NEMA 2 hole terminals shall be used at all locations where rotation of a single bolted terminal would result in contact or unacceptable clearance with other conductors or the enclosure, and for terminations of conductors sized 2 AWG and larger.

5. The manufacturer shall be able to demonstrate fifteen years of actual field experience for the medium voltage terminations, and suitable accelerated and real time testing of weathering resistance for each product to be provided. Test reports shall be available upon request that verify stability with time, temperature, and stress variations.

6. 25 kV terminations shall be TE Ray Chem, or approved equal.

7. 25 kV cable shall be spliced with approved cable splice kits.

PART 3 – EXECUTION

3.01 GENERAL GROUNDING REQUIREMENTS

A. Provide and install conductors of the sizes and types shown.

B. Inspect all wire and cable for damage prior to installation. Damaged cable shall not be installed.

C. In raceways where ac conductors are installed, a separate ground wire shall be provided, sized in accordance with NEC, and installed in accordance with Section 34 21 27 – Traction Power Grounding and Bonding. Ground wires are not required in empty raceways.

D. Manholes, handholes, raceways, and duct banks shall be dewatered and shall be kept dry until the cable is pulled in and any necessary spices are made up. Provide ventilation to disperse any collection of noxious gases.

E. Cables installed vertically shall be supported in accordance with the National Electrical Code, and every fifty feet, minimum. The supports shall be a basket grip, stainless steel material, designed for installation inside the conduit, and of a type approved by the cable manufacturer. Supports that use “wedges” or rely upon the compression of the insulation shall not be used. Supports, which are not specifically manufactured for the purpose, shall not be used. The cable support method shall be approved by VTA before cables are installed in vertical conduits.

F. Provide feeder cables as shown in the Contract Drawings. Provide lugs and connect 2 kV dc cables to supplied switchgear.

G. Install conductors in a raceway. Exposed conductors are not permitted except specifically where leaving or entering cable tray in lengths of 24 inches or less.

The installation methods and materials for each location shall be approved by VTA.

H. The size of wire appears on the drawings where the required ampacity is known. Where the requirements are not known, the conductors shall be sized in accordance with NEC for 75°C in conduit.

I. Soldering of conductors is not permitted.

J. All wire shall be continuous from box to box, pole to pole, and outlet to outlet. Splices shall be made only in outlets, pole bases, boxes, manholes and handholes.

K. No splices or taps shall be permitted in service feeder conductors. Splices in branch circuits or feeders are permitted only in outlet, pull or junction boxes where circuits divide.

L. When splicing or terminating, carefully remove conductor insulation without injury to the conductor. When terminating in lugs, leave the insulation intact up to terminals. Conductor insulation shall butt to the lug shoulder without exposed conductor showing.

M. Compression splices and terminations shall be installed in accordance with the manufacturer's recommendations. Splices and terminations for conductor sizes 2 AWG and below may be made with a mechanical indenter tool. Splices and terminations larger than 2 AWG shall be made with a hydraulic hexagonal jawed tool, as manufactured by Thomas and Betts, or approved equal.

N. Dc Feeder and Negative Cables

1. Every cable and wire shall have an identification tag connected to it at its termination points.

2. Notify the VTA Authorized Representative one day prior to pulling any cable. All cable pulls shall be in the presence of the VTA Authorized Representative. All cable pulling tensions shall be recorded and retained. VTA shall be notified if the actual pulling tensions exceed the calculated pulling tensions.

3. Traction power system cables shall be continuous without splices, unless specifically allowed by the Contract Drawings or as indicated herein. In addition to the splices shown on the Contract Drawings, the Contractor shall

furnish and install any additional splices needed as determined by the Contractor's cable pulling tension calculations or site-specific pulling constraints. The locations of the additional splices shall be subject to VTA review. The additional splices shall be provided at no additional cost to VTA. Where splicing of traction power system cables has been specifically allowed or required, such splicing shall be made only in manholes. Splicing shall conform to the following requirements:

4. Conductors to be spliced shall be firmly connected by means of hydraulic applied compression type NEMA 2 hole lugs. Either "tee" or "crab" type connector assemblies meeting the requirements of this section shall be utilized.

5. The directions of the manufacturer of the splicing kit being used shall be followed exactly.

6. After installing the manufacturer's watertight boots or similar provisions, apply an additional layer of heat-shrinkable sleeving and waterproofing tapes at cable/assembly juncture points.

7. Splices shall be made only by personnel experienced and certified in such work.

8. All cables and cable splices shall be adequately supported by fiber glass cable racks and stainless steel cable fasteners.

9. Notify the VTA Authorized Representative one day prior to performing splicing. If requested by VTA Authorized Representative, splicing shall be made in the presence of the VTA Authorized Representative.

10. Positive and negative cables shall be installed in separate raceways. Maintain the clearance as indicated between positive and negative cables in the traction power substations. Where not specifically indicated on the Contract Drawings, install cables to achieve the maximum practical clearance between the positive and negative cables.

11. Copper wires for bonding and grounding shall not be run in raceways or ductbanks which carry positive or negative dc cables.

12. Wrap all new cables in manholes with fire resistant tape.

3.02 GENERAL REQUIREMENTS FOR INSTALLATION OF WIRE IN RACEWAYS

A. Conductors (wire or cable) shall not be pulled in raceways, conduit, or tray, until all bushings are installed and raceway terminations are completed. Conductors shall not be left extending out of conduit stubs or raceways, and shall be enclosed and protected at all times.

B. Cable shall be protected from damage at all times during installation, and shall never be dragged along the ground, or over stairways or obstacles. After installation, conductor ends shall be sealed using approved end caps, or immediately terminated.

C. Conductors shall be fed directly from reels or boxes straight and parallel into conduits, and never pulled over the edges of boxes or conduits. Crossovers or kinks, which can increase pulling tensions and result in damage to conductors or insulation, shall be avoided. Wherever the wire or cable has been kinked or crossed during pulling, or if VTA determines the wire and cable is defective or has been damaged, VTA may stop the pull and direct the Contractor to remove the wire or cable from the conduit. All wire or cable that has been removed from raceways or equipment once installed, is regarded as used and defective material and shall immediately be removed from the jobsite. This work plus the related re-installation costs shall be performed at no additional cost to VTA.

D. All conductors shall be installed in a conduit at the same time. Wire or cables must be grouped or bundled and fed directly into conduits, and shall not be individually removed from a raceway, and shall not be pulled into a conduit that already contains conductors.

E. Pulling lubricants shall be used during the pull to reduce friction. The Contractor shall use only the Wire and Cable Manufacturer’s approved pulling compound or lubricant compatible with the cable, as approved by VTA. The lubricant shall be non-hygroscopic and vermin-proof. The pulling lubricant shall be non-petroleum based and of the highest quality. The lubricant shall be used in ample quantity to reduce friction and applied in such a manner that the cable is lubricated throughout the entire length being pulled through the conduit. Residue shall be cleaned from conductors, boxes and equipment after the pull is made.

F. After pulling, any wire or cable with damaged insulation caused by the pulling mandrel or basket shall be removed. All wire and cable shall be identified in accordance with these Specifications.

G. Cable shall be pulled in strict accordance with manufacturer’s recommendations. Wire rope shall not be used to pull cable in non-metallic raceways.

H. Unless ends of pulls are within voice or visual range, two-way radios or portable phones shall be used to maintain contact between teams.

I. Cable feeder tubes and nozzles shall be used on all pulls to protect cables and reduce pulling tensions. Do not pull conductors over the edges of boxes or raceways. A roller- bearing swivel shall be attached between the pulling rope and pulling basket or eye, in order to avoid any tendency to twist the cab.

J. Cable reels shall be set up in tandem so that cable may be fed into the raceways without changing direction of bend. Supply reels shall be turned while pulling cable to assist in reducing tension.

K. Cable shall not be pulled by conductors unless contaminants and moisture can be sealed out of the cable. Where pulling grips are used, damaged ends shall be removed as soon as cable has been installed. Cable ends shall be sealed with caps at conclusion of pulling. Temporary cable tags shall be attached to the cable as soon as it is pulled.

L. Whenever a cable is cut, the ends shall be sealed by caps and tape to prevent entrance of dirt and moisture before permanent connections are made. Cut ends of cable, whether on reels or in raceways, shall not be allowed to remain exposed.

M. If the Contractor observes manufacturing defects in cable being pulled, such cable shall be replaced.

N. All conductors shall be installed in a raceway. Exposed conductors are not permitted except specifically where leaving or entering cable tray in lengths or less, as of 24 inches shown on the drawings and otherwise specifically detailed in this specification. The installation methods and materials for each location shall be approved by VTA.

O. Circuit Separation

1. Circuits of different voltages or systems shall be physically separated to reduce the possibility of unsafe conditions, interference, or equipment damage.

2. The following major circuit groups shall not be harnessed or bundled together, shall not run in the same conduit or cable tray, and shall be physically separated and secured in enclosures, junction boxes, or termination in equipment:

3. High voltage ac circuits

4. Dc traction power voltage circuits

5. Low voltage ac circuits

6. Dc control voltage level circuits

7. Semiconductor voltage level circuits

8. Wiring operating at potentials differing by 50 V or more shall not be harnessed or cabled together or be run in the same conduit or duct together. Wiring of different potential in manholes, handholes, electrical enclosures or junction boxes, shall be separated by a rigid physical barrier, such as rigid electrical laminate.

9. Wiring of different potentials within equipment enclosures shall be separated, routed, and secured such that contact or effects from EMI or faults between wiring of different systems is not possible. All wiring within an enclosure shall be insulated for the highest voltage in the enclosure, unless approved otherwise.

10. Separation and/or electromagnetic shielding shall be provided between the conductors of high current switching or transient generating equipment and the wiring of semiconductor, logic, or communication circuits such that interference does not occur between circuits.

P. Wiring Within Enclosures

The requirements below apply to all electrical equipment enclosures, including junction boxes:

1. All wiring within enclosures shall be attached to conductor supports rigidly fastened to the enclosure structure. Wiring supports shall be free from edges, bolt heads, or similar areas, and shall not interfere with nor contact enclosure covers.

2. Wiring entering any removable enclosure shall be harnessed and secured to facilitate removal. Wires from different wire runs shall not be harnessed together or with internal wiring.

3. All wiring shall be secured such that there is no strain on wire terminals, multi- pin connector pins, or other wire termination hardware.

4. Wire dress shall allow for sufficient slack at terminals to provide for shock

and vibration induced movements, equipment shifting, alignment, and cover removal and component replacement. Sufficient additional wire length shall be provided for re-termination of wires without excess tension or splicing as follows:

a. No. 10 and smaller – Three re-terminations

b. No. 8 and larger – Two re-terminations

5. All wire shall be installed as continuous lengths inside the substations, without splices between terminations.

6. Use ringed type lugs.

7. Provide terminal blocks with capture screws and insulated covers.

3.03 INSTALLATION OF CABLE IN TRAY

A. Only cable UL approved for use in tray may be used for this application.

B. Cable shall be placed in cable tray by hand, not pulled, except where pulling calculations and an installation method has been approved as permitted by other parts of this specification.

C. The cable tray shall be sized for one layer of cables. The cables shall be run parallel to each other, without crossing, except where entering and exiting the tray. Cables shall be securely fastened every 18 inches or less to the rungs of the tray using nylon wire ties.

D. Where cables enter or exit the tray, fittings shall be used. Vertical tray fittings shall be used where cable drops out of the tray to limit cable bending to greater than 12 times the diameter of the cable, and to protect the cable from sharp edges of the tray.

E. Rubber tray insulation to protect the cable jacket from damage shall not be used unless approved for the purpose.

3.04 INSTALLATION OF CABLE IN CONDUIT WITH POWER WINCHES

A. The Contractor may decide whether to install conductors in conduit by hand or with power winches. Six hundred volt conductors No. 2 AWG and smaller may be installed using a spring steel tape, and conductors pulled in conduit by hand, at the Contractor’s option. For larger conductors or cables, consideration shall be given to the use of power winches for installation. Other factors to be considered include the size and weight of conductors, and length of conduit run, subject to the approval of pulling and installation requirements of other parts of these Specifications.

B. Power pulling equipment, including the power winch, rope, sheaves, mandrels, baskets and attachments, shall be manufactured for the purpose of pulling wire, and shall be by Greenlee, or approved equal. The winch shall be equipped with a pulling tension device to accurately and continuously monitor the tension.

C. A setscrew mandrel type device or a basket grip type device manufactured for the purpose shall be used to attach the cable to the pulling rope. Attachment by other means is not permissible. A swivel shall be placed between the pulling rope and the device used to grip the wire or cable.

D. Cable reels shall be free from damage, and turn freely. The cable reels shall be mounted level on reel jacks, and positioned for the removal of cable by hand. Adequate means shall be provided to prevent physical contact of wire and cable with abrasive surfaces such as the edges of manholes, and conduit ends. Pulleys and sheaves may be used to direct the wire or cable into conduits; however the diameter of the pulleys shall not be smaller than the minimum conductor-bending radius.

E. The Contractor shall develop a cable installation plan for each conduit run where cable is to be installed using power winches, and address the following considerations:

1. Cable Pulling calculations, including calculated maximum permissible tensions for the exact cable to be installed as required in other Sections

2. The equipment set-up including sheave and reel diameters, and installation methods, including methods to protect cable during installation

F. Pulling tension shall be continuously monitored for each pull, and the maximum values recorded and submitted to VTA. Pulling tension shall not exceed the manufacturers recommended values, as determined by actual pulling calculations.

G. Two-way communication between pulling and feed ends shall be established before and during the installation. Pulling shall be done at a constant velocity, and the pay-off reel shall be tended throughout the pull. Once a wire or cable pull is started, it shall proceed without stopping until completion.

H. Bending radius during installation, including pulleys and sheaves, shall not be less than 12 times the wire or cable diameter. The cable shall be fed straight into the duct in the pay-off manhole or handhole and straight out of the duct at the pulling manhole or handhole.

3.05 INSTALLATION OF CONDUCTORS IN MANHOLES AND HANDHOLES

A. Wire and cable shall not be pulled through manholes or handholes, except where specifically shown on the Contract Drawings or approved by VTA. Cable shall not be pulled in two directions from a manhole or handhole unless the cable manhole or handhole cover opening is equal to 24 times the diameter of the cable, and the Contractor can establish that the cable can be installed without exceeding the cable minimum bending radius. Cable sheaves or pulleys shall not be used in manholes for installation of wire or cable unless specifically approved by VTA.

B. Cable racks shall be provided with the manholes and handholes, and installed in this Contract. The drawings show typical details for cable installation in manhole, which shall be followed to the extent possible, except the general arrangement of cables. The cable placement and racking may be changed for the optimum arrangement, as approved by VTA.

C. Cables shall be trained as close to the manhole or handhole walls as possible and still retain the minimum cable-bending radius. Cable racks shall be adjusted for optimum support of cables and spliced. Racks shall be added as necessary so that two racks support each splice, one on either end of the splice. Cables shall be securely fastened to the racks using wire ties, ¼ inch or larger.

D. All cable ends shall be terminated or capped immediately after installation. Wire or cable that has been left un-terminated or capped in a wet environment, or in a manhole or handhole shall be dried in accordance with these specifications before being terminated, capped, or spliced.

3.06 WIRE AND CONDUIT MARKING

A. The Contractor shall label all conductors in accordance with the approved labeling system, and as shown on manufacturer's approved schematic diagrams.

B. All field installed wire and cable shall be clearly identified at both ends. Dc feeder cables shall be identified by the designation shown on the drawings or as approved by VTA, by using embossed or engraved brass or stainless steel tags attached to the cables with plastic wire ties, in each junction box, manhole, handhole, and where stubbed up into equipment or pole bases, in accordance with Contract Drawings.

C. For 120/240 Vac single phase circuits, the conductors shall be identified by color according to phase:

1. Line – Black
2. Neutral – White
3. Ground – Green

D. For dc circuits, conductors shall be identified by color according to polarity:

1. Positive – Red

2. Negative – Black

E. Control wiring terminals shall be marked using white or yellow permanent concentric polyolefin or PVC markers, with black machine applied printing using permanent ink. Labels using hand printing, or tape labels of any kind are prohibited. The markers shall be oil and grease resistant and shall withstand all combinations of ambient and equipment temperatures.

F. Each control wire shall be labeled with both its circuit designation, and if attached to a terminal, it's terminal designation. All control wires shall be marked within 3 inches of the end of the wire.

G. Exposed conduits containing 2 kV circuits or feeder circuits shall be marked every 10 feet with permanent signs reading "DANGER – HIGH VOLTAGE."

3.07 FIREPROOFING

A. Install fireproofing tape 3M, type 77 Fire and Electric Arc Proofing Tape, or approved equal, in all manholes, cable vaults, and where exposed internal to prefabricated elevated structures.

B. Tape shall be self-extinguishing, at least 0.30 inch thick, and shall be compatible with conductor insulation and jacket.

C. Tape shall not deteriorate when subjected to water, salt water, gases, and/or sewage.

D. Wrap fire proofing tape in half-lapped layers conforming to cable. Place approved bands at the ends of wrapping to hold fireproofing in place.

3.08 CABLE PULLING CALCULATIONS

A. The Contractor shall perform pulling calculations in accordance with the cable manufacturer's recommendations, and these specifications. Calculations shall be made for all conductors including ac and dc power cable, and multi-conductor control cable when installed in conduit under the following conditions:

1. The conduit run exceeds 100 feet vertically.

2. The conduit run exceeds 300 feet horizontally and the conduit run contains a total of over 180 degrees of bend.

3. The Contractor shall also provide calculations for any additional run under

any condition when requested by VTA. The calculations shall establish that the Contractor's cable installation can be implemented without damage to any wire or cable.

B. For pulling calculations, consideration shall be given to the following parameters – fill, coefficient of friction, clearance, configuration, jam ratio of the cables and conduit, weight correction factor, bend radii, training of the cables on entering and exiting the conduits, maximum allowable tension, sidewall load, the method of attaching the conductors to the pulling equipment, and weight of the cables. These factors shall be calculated for each pull as required. The Contractor shall not exceed the maximum allowable values of sidewall pressure, pulling strain on conductors or sheath, limits of pulling device, and pulling tension.

C. In general, the Contractor shall not exceed the following guidelines:

1. The maximum pulling strain on the cable with a pulling eye attached to the conductors is a function of the conductor area as follows: TM = 0.008 x n x CM., where TM = Maximum tension (lbs.), n = number of conductors, CM = area of each conductor (circular mils).

2. When a basket-weave grip is used in lieu of a pulling eye, the maximum tension shall not exceed the value calculated for the pulling eye method or 1000 lbs. per grip, whichever is less.

3. The sidewall pressure loads shall not exceed 300 lb./ft. of bend radius, or the Wire and Cable Manufacturer's recommendation, whichever is less.

4. The jam ratio shall not fall between 2.8 and 3.2.

5. The coefficient of friction for the cables with lubrication shall be taken to be 0.35.

D. Cable pulling calculations shall be submitted to VTA for approval. Cable shall not be installed until the Contractor receives approval from VTA for both the pulling calculations and the cable installation.

3.09 TESTS

Tests shall be performed in accordance with Section 34 21 63 – Testing and Commissioning.

END OF SECTION 34 21 28

SECTION 34 21 33

WORK AT NEW TRACTION POWER SUBSTATION SITES

PART 1 - GENERAL

1.01 SUMMARY

A. This Section covers the construction and coordination requirements for new traction power substation sites including the pads, walls, pull boxes, conduits, grounding mats, and all ancillary facilities as well as the coordination requirements at two new substation sites. Work at substation sites includes civil, structural, mechanical and electrical work and excavation, backfill and paving as specified in these technical specifications and as indicated on the Plans.

B. New substation sites have been roughly graded and leveled by others. Contractor shall perform final grading as required as shown on the Plans. Drawings of the site civil location and site Plans are included in the Contract Documents for reference.

C. The work at the new substation sites shall include all ductwork within the substation site unless otherwise indicated, including all interconnecting ductwork and construction of complete duct bank and connection to the existing Combined System Duct (CSD) interface point. Work at substation sites shall include ductwork, substation enclosure grounding grid, cable racks and hooks, and all other materials, such as anchor bolt embedment and fastening devices in accordance with the unit substation supplier and utility requirements. Work at the substation sites shall also include earthwork, site drainage and construction of asphalt concrete pavement. Work at substation site shall include related grounding and testing.

D. Contractor shall be responsible for the coordination between the equipment supplier requirements and the positioning of stub-ups, substation housing anchors, grounding grid risers and other critical placement items.

1.02 REFERENCE STANDARDS

A. Referenced standards and codes, whether or not cited in this Section, are minimum requirements. The interpretation or the applicability of the referenced standards for products specified in this Section shall be decided by VTA, whose decision shall be final.

1.03 SUBMITTALS

A. Refer to Section 01 33 00 – Submittals.

B. Submit Contractor's proposed details for conduits including stub-up design, location and spacing, within the substation foundation and outside the substation.

C. Submit Contractor's proposed details for capping and waterproofing stub-ups and conduit penetrations that are left unused.

D. Submit product data on all proposed materials including aggregate base, paving, concrete, reinforcing steel, anchor bolts, grounding materials, conduits, pull boxes and all ancillary items.

1.04 MEASUREMENT AND PAYMENT

A. Measurement: TPSS Testing and Commissioning shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for work at new Traction Power Substation sites shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing the work at new Traction Power Substation sites complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed thereafter.

1. Payment will be made at the Contract unit price under:

a.	2.5 MW Traction Power Substation #33 Site Work	LS
b.	2.5 MW Traction Power Substation #34 Site Work	LS

1.05 QUALITY CONTROL

Refer to General Conditions GC-47, Quality Assurance Program, for general requirements and procedures.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Anchor bolts, fasteners, embedded steel angle, and studs used to attach the unit substation to its foundation shall conform to the requirements of the manufacturer's recommendations.

B. Conduit size and type shall be as shown on the Plans. Conduit stub-ups shall match the requirements of the substations as specified under this contract.

C. All Railings, if required, shall be made detachable for the ease of equipment removal when required. All steel parts shall be galvanized.

D. Other materials shall be as specified elsewhere in these technical specifications.

PART 3 - EXECUTION

3.01 GENERAL

A. Contractor shall stake out the locations and footing of substation foundation, concrete foundation and utility manholes based on the track stationing offsets as a reference datum. The alignment with grade and dimension shall be as shown on the Contract Plans.

B. Structural members of foundations shall be level and plumb.

C. Contractor shall seal solid gaps between substation base and foundation.

D. Unit substation enclosures shall be grounded from within at all corners. Contractor shall confirm with the unit substation manufacturer that all corners that are to be grounded and accordingly ensure that the ground risers from the grounding grid are appropriate.

E. Contractor shall check and ensure that all ducts set in the foundations are in accordance with the Contract Plans and have been coordinated with the respective manufacturers' requirements, and comply with VTA LRT Standard Specifications before concrete placement.

F. Stub-ups/conduit penetrations in foundations or concrete work left unused shall be capped and waterproofed.

G. At new substation locations, the contractor shall fully install the unit substations and make all necessary connections of power, grounding and external control cables in accordance with the cable supplier's recommendations, the requirements of the unit substation supplier and as shown on the Plans.

END OF SECTION 34 21 33

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SECTION 34 21 53

TRACTION POWER SUBSTATION FIELD INSTALLATION

PART 1 - GENERAL

1.01 SUMMARY

A. This Section covers the requirements for field installation and providing installation assistance for the two new 2.5 MW traction power substations, TPSS #33 and TPSS #34.

1.02 REFERENCE STANDARDS

B. Referenced standards and codes, whether or not cited in this Section, are minimum requirements. The interpretation or the applicability of the referenced standards for products specified in this Section shall be decided by VTA, whose decision shall be final.

C. Work described in this Section shall be performed in accordance with NEC, local codes and regulations, manufacturers' recommendations as approved by VTA, and in accordance with these Specifications. A listing of other standards and codes applicable to this Contract is supplied in individual specification Sections.

Organization	Number	Title
ASTM	AS-123	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM	D 150	Standard Test Methods for Ac Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulation
ASTM	C-413	Standard Test Method for Absorption of Chemical-Resistant Mortars, Grouts, and Monolithic Surfacings, and Polymer Concretes
ASTM	C-579	Standard Test Methods for Compressive Strength of Chemical- Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes

ASTM	C-589	Apparent Impact Strength of Preformed Block Type
ASTM	D-2794	Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact)
AWS	QCI	Standard for AWS Certification of Welding Inspectors
NFPA	70	National Electrical Code
UL	94	Test for Flammability of Plastic Materials for Parts in Devices and Appliances

1.03 SUBMITTALS

A. Refer to Section 01 33 00 – Submittals.

B. Factory installation plan within 120 days after NTP.

C. Field installation plan within 180 days after NTP. Field installation plan shall include TPSS building setting plan, diagram showing position of track and crane, and description of steps involved with the TPSS building installation.

D. Certified floor layout of all equipment to be mounted and assembled in TPSS within 120 days after NTP.

E. Plan containing methods and schedule of demolition in conformance with CAL/OSHA construction safety orders and other regulatory authorities within 120 days after NTP.

1.04 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed thereafter.

1.05 RELATED SECTIONS

All Division 34 21 Sections.

1.06 QUALITY CONTROL

Refer to General Conditions GC-47, Quality Assurance Program, for general requirements and procedures.

1.07 QUALITY ASSURANCE

A. All materials used in the factory and field installation of the traction electrification system shall be of high quality. All workmanship shall be of a high standard and shall conform in all respects to the best installation practices for electrical installations, and traction electrification systems.

B. The Traction Power Substation installations shall comply with the requirements of Cal. PUC G.O. 95, Rules for Overhead Electric Line Construction, and Cal. PUC G.O. 128, Rules for Construction of Underground Electric Supply and Communication Systems.

1.08 GENERAL REQUIREMENTS

A. All Work specified in this Section, shall be performed under the direct supervision of the Traction Electrification System (TES) Substation manufacturer and manufacturer's Field Service Engineer, who shall be on-site to coordinate and direct the Work.

B. All equipment shall be located and installed in accordance with the Contract Documents and approved shop Drawings. The Contractor shall make minor changes in location of exposed conduits, cable tray, or equipment, prior to installation as directed by VTA at no additional cost.

C. Electrical Inspection

1. VTA may observe all field electrical inspections.

2. Electrical inspections shall be scheduled a minimum of seven days in advance with VTA and the State or local Electrical Inspector.

3. All corrections directed by the electrical inspection shall be performed by the Contractor at no additional cost.

PART 2 - PRODUCTS

2.01 GENERAL

A. Overall Requirements. This Section specifies the overall requirements for the field installation of substation enclosures and substation equipment. Ensure substations are alike in every respect in functional and physical characteristics, both internally and externally. Provide all functions and devices as described and indicated in the Contract

Documents.

1. Substations have been completely assembled, wired, tested, and installed in compact, weather- tight, self-supporting, transportable, outdoor enclosures at the Contractor's factory.

2. Substations had been fully tested and ready for energization upon delivery at the site and ready for connection to utility interface point, and positive feeder, negative return and negative drainage cables.

B. Substation Equipment. Refer to the Contract Documents, Section 34 21 16 for the equipment and materials furnished as part of each substation

C. Lifting Lugs. Provide removable lifting lugs on the enclosure base to lift the complete substation without any damage to the structure or any of its components.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Substation Installation. Installation of the two outdoor substations to be as indicated in the Contract Documents.

1. Work includes delivery of each substation to its specific site including setting on the substation pad and, following connection as described below, provision of field technical services.

2. Field technical services shall provide engineering assistance during the installation, connection and testing of the substation. The Contractor's technical assistance shall address the handling, connection and installation of the specialized traction power substation equipment. The Contractor is to retain full responsibility for safe handling, setting and installation of the equipment.

3. Scheduling. Contractor shall work with VTA to coordinate and schedule the delivery, unloading, and setting of the substation as described to the Special Conditions SC-9, Delivery, Unloading and Storage. Schedule to be set so that Contractor's field representative is available to be present during all activities that involve moving and setting of the substation.

4. Substations are not to be delivered to the site until the substation foundation is complete and accepted for purposes of substation installation by VTA.

B. Off-Loading and Setting. Substation off-loading and setting at site from the delivery vehicle will be under this Contract.

1. VTA will inspect the substation at the delivery site before and immediately after off-loading. Contractor is responsible for repairing any defects resulting from moving and setting the substation.

2. The following work related to equipment that are part of the substations and may be packed separately shall be performed by the Contractor:

   a. Unload and uncrate items shipped separately and dispose of the crates. Remove shipping preparations including blocking, covers, packaging and other temporary provisions made after setting the substation on the foundation.

   b. Install gutters and downspouts

   c. Uncrate and install AC and DC circuit breaker elements and arc chutes under the supervision of the substation supplier's field technical services representative.

   d. Install lamps for house lighting.

   e. Install exterior lighting fixtures.

   f. Provide a temporary generator to charge the batteries prior to connection of utility service by the utility.

   g. Clean the interior and exterior of the substation and touch-up paint finishes damaged during installation.

   h. Install any other equipment shipped separately.

3. Work not in contract: The following work is not in this contract:

   a. The utility will provide high voltage AC cable and connections to the substation as indicated in the Contract Documents.

4. Connect the ground mat indicated in the Contract Documents, and as specified herein, to ground plates on the interior of the substations. Connect the ground mat to AC equipment ground buses as indicated in the Contract Documents.

END OF SECTION 34 21 53

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SECTION 34 21 62

TECHNICAL SUPPORT

PART 1 - GENERAL

1.01 SUMMARY

A. This Section describes the technical support services and equipment to be provided for this Contract including:

1. On-Call Support
2. Maintenance
3. Warranty

1.02 REFERENCED STANDARDS

Not Used.

1.03 SUBMITTALS

A. System Maintenance Plan: Contractor shall develop a detailed system maintenance plan for the equipment furnished under this Contract. The system maintenance plan shall be provided for VTA approval 30 days prior to on-site operational tests. The system maintenance plan shall be developed with close coordination with VTA and shall be consistent with VTA's established maintenance approach. VTA’s concept for restoration to service given a failure is to remove and replace the Lowest Replacement Units (LRUs). The system maintenance plan shall describe all required corrective and preventive maintenance activities. The system maintenance plan shall include the following:

1. Maintenance staff requirements
2. List and description of the LRUs
3. Description of diagnostic and test equipment
4. Corrective maintenance procedures
5. Preventive maintenance procedures
6. Recommended preventive maintenance schedule

7. Description of the O & M manuals. O & M Manuals in addition to requirement specified in 01 78 23 - Operational and Maintenance Data shall contain TPSS default settings and configuration instructions.

1.04 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed thereafter.

1.05 TECHNICAL SUPPORT AND MAINTENANCE

A. During the warranty period, or a minimum of six months following the Contractor and VTA agreed in-service date, whichever is longer, the Contractor shall provide on-call technical support. If during the warranty period, VTA determines the equipment and material installed under this Contract is not conforming to the equipment reliability requirements or system availability requirements, the Contractor shall provide on-site technical support to fully understand the problems identified and to correct the deficiencies.

B. The Contractor must provide 6 months of on-call technical support for VTA maintenance staff after project completion to ensure a smooth transition of the system.

C. Contractor shall perform all maintenance on the equipment furnished and installed under this Contract from the time that the equipment is installed until Final Acceptance.

1. Contractor shall maintain records of all spare equipment utilized in maintenance and the replacement of spare equipment for items covered under warranty. Any equipment removed from service shall be made available to VTA for inspection.

2. Contractor shall commence repair of any subsystem that fails within 24 hours of notification of the failure by VTA or discovery of the failure by Contractor's personnel. Contractor shall notify VTA immediately upon discovery of an equipment failure and shall provide written notification within 24 hours.

3. Contractor shall perform all routine and preventive maintenance for the equipment furnished and installed under this Contract in accordance with the equipment manufacturer recommendations.

D. Prior to Final Acceptance, the Contractor shall furnish required spare parts as required by Specification 01 78 43 – Spare Parts.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

Not Used

END OF SECTION 34 21 62

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SECTION 34 21 63

TESTING AND COMMISSIONING

PART 1 - GENERAL

1.01 SUMMARY

A. This Section covers the factory and field tests to be performed by the Contractor on all new equipment, materials, devices, components, and accessories required for mainline TPSS #33 and TPSS #34 and modified equipment at TPSS #28.

B. This Section describes the necessary tests to be performed, and the criteria and requirements for test planning, performance, recording of data, and reporting of test results.

1.02 REFERENCE STANDARDS

A. Standards for Testing including all applicable ANSI, IEEE, NEMA, UL, and other standards that govern the requirements of design, manufacturing, and assembly of the switchgear, pad mounted tie breakers, dc feeder cables, and components.

B. Referenced standards and codes, whether or not cited in this Section, are minimum requirements. The interpretation or the applicability of the referenced standards for products specified in this Section shall be decided by VTA, whose decision shall be final.

1.03 SUBMITTALS

A. Refer to Section 01 33 00 – Submittals.

B. One original and five copies of the results of each test shall be submitted. The original of the test results shall contain the original test forms filled out by the company performing the tests with original signatures.

C. Test Program Plan: Submit within 60 days after Notice to Proceed for approval by VTA.

D. Test Procedures: Submit for approval of each test procedure a description with pass/fail criteria and test data sheets, accompanied by a cover letter with reference number, at least 30 calendar days prior to the scheduled performance of each test. All test procedures shall be submitted to VTA for approval. Tests shall not commence without approved test procedures by VTA.

E. Test Results: Results of each test shall be recorded and the test result documented in test reports shall be furnished to VTA within 14 calendar days of completion of the test. Certified test results shall also be furnished for tests performed by any subcontractors when such tests are a requirement of these Specifications.

1. The test procedures used

2. The completed, signed test forms

3. Test summary

4. Test reports: Reports shall include documentation of the calibration date of each instrument used during the test. The calibration of each instrument shall be certified by a recognized testing facility every 90 days or less.

F. All test reports shall be checked and approved by Contractor prior to submittal to VTA.

G. After completion by factory or field test personnel and checked for accuracy and completeness, the data sheet shall be submitted as part of the test report. The test report shall also contain a final description sheet on which Contractor shall record discrepancies found and action taken. This documentation shall be furnished to VTA. All test reports shall be dated and signed by the responsible representative of Contractor on the day the test is performed. Space shall also be provided for the signature of VTA's witnessing inspector. The report shall show the specific test instruments used on each test, with the instruments identified by name, type, serial number, and calibration due date.

1.04 MEASUREMENT AND PAYMENT

A. Measurement: TPSS Testing and Commissioning shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for TPSS Testing and Commissioning shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing TPSS Testing and Commissioning complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed thereafter.

1. Payment will be made at the Contract unit price under:

a. TPSS Testing and Commissioning including: LS
   Factory design tests
   Factory production tests

Field and acceptance test
Integrated system testing

1.05 QUALITY CONTROL

Refer to General Conditions GC-47, Quality Assurance Program, for general requirements and procedures.

1.06 GENERAL REQUIREMENTS

A. Factory Tests (design and production): Contractor shall provide, without charge, access to the facilities to satisfy VTA that materials and equipment being furnished are in accordance with the applicable standards and contract documents.

B. Coordination: Contractor shall closely coordinate all factory tests (design and production) tests, field installation and final assembly tests with VTA. If any test is not in accordance with the instructions, it immediately shall be brought to VTA's attention.

C. Contractor shall perform all work necessary for planning and conducting of the required tests. The Contractor shall also prepare the required documentation for the performed tests.

D. When any system or subsystem does not meet the requirements of this Specification, the Contractor shall be responsible for making necessary corrections and retesting to prove compliance and acceptance by VTA.

E. Test Witnessing: VTA reserves the right to witness all tests whether conducted by the Contractor, by an independent agency, or by the Contractor's suppliers. If VTA decides not to witness a test or tests, test reports shall still be submitted to VTA for approval. Test reports shall be fully documented in accordance with the test report requirements and shall be signed and certified by all witnessing parties. Testing shall not commence until all design affecting the respective equipment has been approved.

F. Responsibility: Contractor shall be responsible for all tests performed under this Contract. Contractor shall furnish all test instruments and other equipment and materials necessary for performing all tests required prior to shipment and in the field. All test equipment shall be calibrated within 90 days prior to use, unless otherwise approved by VTA. Proof of calibration shall be submitted with all test reports. Should there be any loss of equipment or damage to such equipment as a result of tests, the Contractor shall be fully responsible for replacing the damaged equipment and/or repairing such equipment. Replacement of damaged equipment shall include all costs, including but not limited to, removing damaged equipment, furnishing, transporting, and installing replacement equipment, and retesting.

G. Rejection and Retesting: Failure of equipment to meet test specifications or ratings is grounds for rejection of equipment. Rejected equipment shall be retested after reworking. If modifications or changes affect any drawings, diagrams, or other documents previously submitted to and accepted by VTA, revised drawings or diagrams shall be submitted for VTA's approval to show proposed changes before changes or modifications are made on the equipment. Modifications or changes which do not warrant revision of a drawing still to be furnished to VTA with notice of the retest schedule. If it is not practicable to rework rejected equipment, new equipment shall be manufactured. The requirements for drawings and design calculations of the original unit shall be applicable to the new unit. The entire cost of the rework or the new unit shall be borne by the Contractor, including retesting and the costs incurred by VTA of witnessing the retesting. Time extensions due to failure of equipment to meet the test specifications will not be granted.

H. In the event that the Contractor’s rescheduling or delay of factory tests causes the VTA airfare and hotel costs to increase, then the Contractor shall, at no cost to VTA, pay for the resultant differential travel expenses. If any test fails and re-testing at a later date is required, the contractor shall be responsible for the cost of the VTA inspector witnessing the test. All re-tests shall be witnessed.

I. Test Waiving: The Contractor may submit previous certified test reports in lieu of performing tests for the approval of VTA. Certified test results shall be for matching model numbers and within the last five years.

PART 2 - PRODUCTS

2.01 TEST PROGRAM PLAN

A. Submit an overall test program plan to VTA for approval. Incorporate all tests specified herein in the test program plan. Use the test program plan as a controlling document for all tests and related activities. Include the following information in the test program plan:

1. Detailed written description of overall test program and objectives

2. Title of each test with reference to the respective article or section number in the Contract Documents

3. General description of each test to be performed Pass/fail criteria for each test

4. Planned sequencing of tests

5. Test location
6. Submittal date of each test procedure, test report, and certified test document
7. Planned starting date of each test
8. Planned completion date of each test
9. Contractor may propose an alternative site for select Substation Field and Acceptance Testing including PG&E inspection before shipping and installation at final location.

2.02 TEST PROCEDURES

A. Develop detailed test procedures for each test. Test procedures shall be stapled or bound in volumes. Individually number each procedure in a logical sequence and number all pages within each procedure. Provide the title, date, and name of individuals who prepared and approved the procedure on the first sheet of the procedure.

B. Based upon the results of the first items tested, revisions to the test procedures may be made if approved by VTA. Resubmit the modified test procedures to VTA for approval. Meet the same submittal requirements unless waived by VTA. Provide each set of procedures with a step-by-step procedure for performing the test and include the following information:

1. Title of test
2. Test objectives
3. References
4. Test location
5. Test date
6. Equipment and instrumentation with the accuracy and calibration data
7. Methodology
8. Test criteria including test setup with circuit diagrams and test sequence
9. Test criteria including data evaluation procedures and test data recording procedures
10. Test data requirements including forms and format for recording data

11. Primary and supporting test agency, and number of personnel required to perform the test, including witnesses

2.03 TEST REPORTS

Include a test report section for each test to document test results. Each test procedure shall have a report section included. Report section shall include the following:

10. Title of test
11. Test objectives
12. Summary and conclusions
13. Location and date of test
14. Expected results
15. Results including tables, curves, photographs, and any additional test data required to support the test results
16. Pass/Fail Criteria
17. Pass/Fail Statement
18. Descriptions of all failures and modifications, including reasons for such failures, and names of individuals approving modifications
19. Calibration due dates of measuring instruments/equipment
20. Calibration certificates of measuring instruments/equipment
21. Abbreviations and references
22. Signatures of test witnesses

PART 3 - EXECUTION

3.01 FACTORY TESTS

A. Factory tests, including design and routine production tests, shall be performed by the Contractor, its supplier, or a testing agency prior to shipment of the equipment. At his expense, Contractor shall conduct pre-delivery tests followed by a formal Factory Acceptance Test (FAT) on each switchgear lineup following completion of manufacture and before delivery.

1. These pre-delivery tests shall include visual and measured inspections, as well as testing the switchgear operation, as indicated in the Contract Documents.

2. Tests shall be conducted and documented in accordance with the Test Program Plan submitted to VTA and subject to VTA's approval. No dc switchgear may be shipped from the final point of manufacturing until VTA's approval of the FAT.

3. The FAT shall be scheduled and conducted with a minimum of 30 calendar days' notice prior to each test so that VTA may schedule personnel to witness the tests. Written results of the FAT, and any other tests, shall be filed with the Assembly Inspection Records.

4. Except where otherwise indicated, VTA may waive the requirements for factory design tests upon approval of test procedures, test reports, and/or certified documentation of like equipment. The test shall have been performed less than five years prior to submitting. Submit test reports on like equipment or materials for the factory design tests that may be waived by VTA. VTA reserves the right of whether or not to waive any test(s) and VTA's decision shall be final.

5. Contractor to submit for approval of VTA a detailed lump sum cost breakdown for the design testing. Submit as a part of the detailed Schedule of Values. In the event any test is waived, a deduction for the cost of the test(s) not conducted shall be based upon the approved breakdown and appropriately made to the contract price for Design Tests.

6. Punch List items identified during FAT shall be completed and signed off by VTA prior to shipping equipment from the supplier's production facility.

B. High Voltage Ac Switchgear

1. Design Tests: The high voltage ac switchgear tests shall be performed on the ac switchgear assembly and each component as listed herein. The tests shall consist of all design tests as specified in ANSI C37.20.3 for metal enclosed switchgear or ANSI C37.20.2 for metal clad switchgear.

2. Production Tests: The following tests shall be performed on each ac switchgear assembly prior to shipment from the factory as described in ANSI C37.20.3 for metal enclosed or ANSI C37.20.2 for metal clad.

    a. Dielectric tests

    b. Mechanical operation tests

c. Electrical operation and control wiring tests, except that the control wiring continuity shall be verified by actual electrical operation of the control devices

d. Grounding of instrument transformer cases

C. High Voltage Ac Circuit Breaker

1. Design Tests: The high voltage ac circuit breaker test shall be performed in accordance with the design tests as described in ANSI C37.09.

2. Production Tests: The following tests shall be performed on each ac circuit breaker prior to mounting inside the ac switchgear, in accordance with ANSI C37.09:

a. Nameplate check

b. Control and secondary wiring checks

c. Clearance and mechanical adjustment check tests

d. Mechanical operation tests

e. Timing tests

f. Stored energy system tests

g. Conductivity of the current path test

h. Low frequency withstand voltage tests on major insulation components

i. Current transformer

j. Resistors and coils

D. Traction Power Transformer

1. Design Tests: The following design tests shall be performed on the traction power transformer as specified in ANSI C57.12.01 and C57.12.91:

a. Resistance measurements of all windings on the rated voltage connection on all tap settings.

b. Impedance and load losses at the rated current on the voltage connections of all windings on all tap settings in accordance with ANSI C34.2. The transformer commutating reactance shall also be calculated from these tests.

c. Short circuit tests as described in ANSI C57.12.91 shall be performed to fully evaluate the capability of all windings. Faults shall be applied to the terminals of each secondary winding. All recommended terminal measurements shall be made, and the data submitted to VTA. VTA shall be the sole judge of the serviceability of the transformer after the completion of design testing

d. Impulse tests shall be performed in accordance with ANSI C57.12.91 with the exception that the waveform used shall be 1.4 x 40 microseconds. The impulse tests shall be performed after completion of the short circuit tests.

e. Temperature tests as described in ANSI C57.12.91 shall be performed at 160.8% of rated current.

2. Production Tests: The following production tests shall be performed on each rectifier transformer:

a. Factory Dielectric tests as described in ANSI C57.12.91.

b. Applied-voltage and induced-voltage tests as described in ANSI C57.12.91.

c. Resistance measurements of all windings on all taps.

d. Ratio tests on the rated voltage connections and on all taps as described in ANSI C57.12.91.

e. Polarity and phase relation as described in ANSI C57.12.91.

f. No-load losses and excitation current as described in ANSI C57.12.91.

g. Audible sound level tests as described in ANSI C57.12.91 except the three foot distance and maximum level in Section 3.3.6 shall apply.

h. Partial discharge test as follows:

1) The transformer shall be subjected to an induced voltage of 1.5 times the rated voltage at a frequency between 100 and 400 Hz.

2) The partial discharge extinction level shall be reached at an induced voltage of not less than 1.2 times the rated line-to-line voltage.

3) The partial discharge extinction level shall be defined as the point when the reading at 1.9 MHz is less than 10 microvolts or 13 picocoulombs.

E. Rectifier

1. Design Tests: The following design tests shall be performed on the rectifier unit:

a. Dielectric tests as specified in ANSI C37.20.1

b. A rated voltage test shall be performed. The rectifier shall be subjected to 110% of the ac rated voltage for a period of 5 minutes with the dc open.

c. A current unbalance test shall be performed. Maximum current unbalance between rectifier legs shall not exceed ±10% when measured between 50% and 150% of the rated capacity. The current unbalance test may be performed during the design test for the transformer-rectifier unit.

d. A loss measurement test for overloads up to 150% shall be performed in accordance with ANSI C34.2, Sections 6.3.2 and 6.3.3.

e. A rated current test, at reduced voltage, including the overloads shown in Figure 3-1 in accordance with ANSI C34.2, shall be performed after temperature stabilization at rated load. The testing shall be performed with one diode removed from each phase arm and shall demonstrate that the maximum safe junction temperature for each diode is not exceeded.

f. Efficiency, voltage regulation, and power factor shall be demonstrated for loads of one, 25, 50, 100, 150, and 450 percent of rated load.

2. Production Tests: The following production tests shall be completed on each rectifier unit:

a. Dielectric tests as specified in Section 5.3.3 of ANSI C34.2

b. Continuity tests and all cables and buses

c. Rated voltage test as specified in Section 5.3.4.1 of ANSI C34.2

F. Dc Circuit Breakers

1. Design Tests: The tests shall be performed in accordance with the design tests as described in ANSI C37.14. The schedule of design tests defined in ANSI C37.14 shall also be followed.

    a. Third party certification is required, and the test lab original documentation shall be incorporated in the test report for VTA's review.

    b. Test results, including dc voltage, arc voltage, inrush current, steady-state fault current, impulse time of faulted unit, clearing time of faulted unit, and primary system capacity shall be recorded on oscillographs. All data recorded on oscillographs shall be properly labeled and identified.

    c. As part of endurance tests, Contractor shall demonstrate that the circuit breaker can successfully undergo at least 1100 no-load operations with servicing every 250 operation as defined in ANSI C37.16. The circuit breaker shall endure 250 operations at full load current per ANSI C37.16 Table 13 requirements.

2. Production Tests: The following tests indicated in ANSI C37.14 as "Production Tests" shall be performed on all dc circuit breakers:

    a. Control and secondary wiring check

    b. Dielectric withstand

    c. Mechanical operation

    d. Calibration

G. Dc Switchgear

1. Design Tests: The following tests, indicated in ANSI C37.20.1 as "Design Tests" shall be performed on one complete dc switchgear assembly consisting of a lineup of one main and four feeder circuit breakers. It is recommended that these design tests be performed in conjunction with the dc circuit breaker design tests.

    a. Dielectric including power frequency withstand, impulse withstand, and bus bar insulation

    b. Rated continuous current

    c. Momentary current

d. Interrupting

e. Mechanical operation (previous certification will be accepted if available)

f. Sequence

g. Flame-retardant test (previous certification will be accepted if available)

2. Production Tests: The following tests indicated in ANSI C37.20.1 as "Production Tests" shall be performed on all dc switchgear assemblies:

a. Dielectric

b. Mechanical operation

c. Electrical operation and control wiring including control wiring continuity, control wiring insulation, polarity, and sequence

H. Motorized and Manual Dc Disconnect Switches

1. Design Test: The disconnect switches shall be tested in accordance with the design tests specified in ANS C37.41 and the appropriate standards.

2. Production Test: Each disconnect switch shall be tested in accordance with the production tests specified in ANSI C37.41.

I. Dc Lightning Arrestors

1. Design Test: Dc lightning arrestors shall be design tested inside the switchgear enclosure, or an identical reproduction of the enclosure, in accordance with ANSI C62.11.

J. Transformer-Rectifier Unit

1. Design Test: The design tests described in this Section shall be performed on the first production transformer-rectifier unit substation. Existing test reports for identical unit can be submitted for the approval of VTA in lieu of this test. The transformer-rectifier unit shall be tested as a complete assembly including interconnecting bus and/or cables and enclosures. Ac and dc switchgear are not a required part of this assembly.

a. Rated current load tests shall be performed at reduced voltage to demonstrate compliance with the requirements specified in Section 26

12 16, Traction Power Transformer-Rectifier Unit. The tests shall verify efficiency, power factor, and voltage regulation at loads of 0%, 100%, 150%, and the duty cycle specified in Figure 3-1 in accordance with ANSI C34.2. Test circuit No. 31, as described in Section 6.3.2.2 of ANSI C34.2, shall be used to make loss measurements at the specified loads. The transformer rectifier shall be operated at 100% load for a minimum of six hours immediately before running the duty cycle tests to assure temperature stabilization.

b. The transformer temperature rise shall be recorded during the rated load tests. Six thermocouples shall be implanted into the secondary windings of the transformer at locations approved by VTA and two thermocouples shall be mounted on the transformer frame. The thermocouple readings shall be continuously recorded during and after the testing. The transformer temperature rise determined by any of the thermocouples shall not exceed the value specified in Section 26 12 16 – Traction Power Transformer-Rectifier Unit.

K. Relays

1. Design Tests: Design tests shall be performed on one relay of each type and rating in accordance with ANSI C37.90, and shall be performed on the first production component of each type. The following specific design tests are required on the Frame Fault Relay (Device 64):

a. The continuous and maximum short circuit ratings shall be demonstrated by test. Response time and maximum trip time shall also be demonstrated by test.

b. Test procedure shall be submitted for approval prior to testing. Graphical test results including time current characteristic curves shall be submitted for review. The maximum trip time for this device shall not exceed 50ms.

2. Production Tests: Production tests shall be performed on all relays in accordance with ANSI C37.90.

L. Meters, Instruments, and Instrument Transformers

1. Design Tests: Design tests shall be performed on one meter, instrument, and instrument transformer of each type and rating in accordance with ANSI C39.1 and C57.13.

2. Production Tests: Production tests shall be performed on all meters,

instruments, and instrument transformers in accordance with ANSI C39.1 and C57.13.

M. Human Machine Interface (HMI) Panel

1. Design Tests: Design tests shall be performed on one HMI panel with all accessories in place.

2. Production Tests: By means of insulation resistance, continuity, and operation tests, HMI panel with all accessories in place shall be production tested for proper operation, accuracy, short-circuits, and open-circuits.

N. Battery

1. Design Test: The design test for the battery shall consist of the "service test" as described in IEEE 450.

2. Production Test: The production tests for the battery shall consist of the acceptance tests as described in IEEE 450. The battery acceptance tests shall be performed after the substation equipment has been installed on site.

3. Battery discharge test shall be conducted as per IEEE 450 at the factory and after the substation equipment has been installed onsite.

O. Battery Charger

1. Design Test: The tests for the battery charger shall consist of the twelve design tests as described in NEMA PE5.

2. Production Test: The production tests for the battery charger shall consist of the acceptance tests as described in NEMA PE5. The battery charger acceptance tests shall be performed after the substation equipment has been installed on site.

3. Battery charger discharge test shall be conducted as per NEMA PE5 at the factory and after the substation equipment has been installed on site.

P. Station Service Transformer

1. Design Test: The following design tests shall be performed as described in ANSI C57.12.91.

a. Resistance Measurement

b. Impedance, Voltage and Load Loss

c. Temperature Rise

d. Impulse, Power Factor, and Insulation Resistance

2. Production Test: The following production tests shall be performed as described in ANSI C57.12.91 for each station service transformer prior to shipment to VTA:

a. Ratio Tests

b. Polarity and Phase Relation

c. No-Load Losses and Excitation Current

d. Applied Voltage and Induced Voltage Dielectric Tests

3.02 TESTING PRIOR TO INSTALLING EQUIPMENT IN SUBSTATION ENCLOSURE

A. Electrically Insulated Floor and Wall Tests:

1. Perform hi-potential dielectric tests on the epoxy floor and wall insulation installed in each traction power substation enclosure prior to the installation of substation equipment.

2. Provide a hi-potential tester with a voltage range of 1-15,000 Vdc and a current range of 0-2000 microamperes dc to perform the tests.

3. Floor: Perform a wet mop test as follows:

a. Provide a sponge mop with a non-metallic handle. Provide a copper plate behind the sponge with a wire terminal to attach the test lead.

b. Connect one lead from the tester to the copper disk and the other lead to the station ac ground bus.

c. Apply 4500 Vdc from the hi-potential tester, using precautions such as insulated boots and hot gloves to protect the test technician.

d. Saturate the mop with saline solution and mop the entire insulated floor with the room darkened. Re-saturate the mop as necessary.

e. Visible arcing shall be indications of inadequate dielectric strength of the epoxy coatings and additional layers of epoxy shall be applied until the leakage current is lower than 50 microamperes.

4. Walls: Perform a copper disk test as follows:

   a. Provide a copper disc 4 inches in diameter and ¼-inch thick. The disk shall have a non-conductive handle and wire terminal to attach the test lead.

   b. Connect one lead from the tester to the copper disk and the other lead to the station ground bus.

   c. Place the copper disc on the wall insulation at a minimum of 10 locations selected by Engineer where the laminate is fastened to the wall with mechanical fasteners.

   d. Apply 4500 Vdc for the 120 seconds and record the leakage current.

   e. If leakage current is greater than 50 microamperes, epoxy insulation shall be applied to the fastener to increase the insulation and the fastener retested.

3.03 TRACTION POWER SUBSTATION FIELD AND ACCEPTANCE

A. General Requirements for Field and Acceptance Testing as required by IEEE 1653.4- 2011:

1. Field tests shall be performed after each new traction power substation has been placed on site. The Contractor shall verify that all equipment is properly installed, in operable condition, and all open inspection items have been resolved. All tests for substation equipment, wire and cable, and electrically insulated walls and floors shall be satisfactorily performed for each location prior to the initiation of the Substation Acceptance tests.

2. After the installation of all equipment and wiring in the new substation and after the modifications to the existing substations, the substation acceptance tests shall be performed. All tests which do not require the energization of the substation shall be completed prior to energizing any portion of the substation.

3. The scope of testing includes, but is not limited to:

   a. Continuity, calibration and electrical operation of all circuits including relays, annunciation, indication, and shutdown functions.

   b. Insulation of all field installed conductors shall be tested.

   c. All equipment shall be given a functional test, and the substation operation and controls verified.

d. Insulation and grounding of all enclosures shall be verified.

e. All remote functions and indications shall be tested using simulated electrical input signals and output loads. This includes the SCADA interface, and transfer trip circuits.

f. The interlocks on the enclosure and building doors and panels shall be checked for proper functioning and operation of shutdown circuitry.

g. Strip chart recorders or oscillographs shall be used as required to provide a permanent record of the protective functions.

h. Other tests shall be performed as required by the substation equipment manufacturer and VTA to determine the acceptability of the installation and equipment.

4. No equipment shall be energized or placed in the operating mode until allowed by VTA.

B. Wiring and Cable Testing

1. After field wiring has been pulled in place and terminations to equipment and devices have been completed, the Contractor shall check installed wiring for accuracy, open circuits, short circuits, ground connections and insulation integrity by means of continuity and insulation tests. These tests shall be performed prior to energizing the equipment.

2. Continuity tests shall be performed with an ohmmeter to check continuity from point to point, and for shorts to ground. Insulation tests shall be performed point to ground with a 1,000 Vdc megohmmeter. The minimum acceptable value shall be 10 megohms measured to ground. Continuity and insulation tests shall be performed with all splices and terminations in the circuit.

3. High potential tests shall be made in accordance with ANSI/IEEE 141. High potential test results shall be submitted to VTA for approval prior to final termination of the cables. The test is passed if there is no insulation breakdown or excessive leakage current. If a failure is detected, the Contractor shall locate and determine the trouble, replace defective wires, cables or components, make necessary corrections to the installation, and retest, without additional cost to VTA.

4. All 600 V control circuit wiring shall be given continuity and insulation tests after termination. Semiconductor devices shall be protected against the test voltage by means of shorting jumpers, if they are not inherently protected by

the circuit in which they are used.

5. All 2 kV wire and cable shall be given continuity and insulation tests, followed by a high potential test of 10 kV for 2 kV insulation. All 25 kV cable shall be given continuity and insulation tests, followed by a high potential test of 100 kV dc for 25 kV 133% insulation.

C. Substation Ground Mats Test

1. Testing of substation ground mat.

    a. Ground test shall be in accordance with IEEE Standard 81. A plot of ground resistance readings for ground mat shall be provided to VTA on 8-1/2 x 11- inch size graph paper. The current reference rod shall be driven at least 100 feet from the ground rod or grid under test. Alternatively, an established metallic ground may be utilized. The measurements shall be made at 10-foot intervals beginning 25 feet from the test electrode and ending 75 feet from it, in direct line between the ground rod or center of grid and the current reference electrode.

2. Testing shall be performed by a certified NETA technician, in accordance with NETA standards.

3. Additional copper cables and ground rods shall be required to achieve a minimum ground resistance of 5 ohms.

4. Provide results to VTA for review.

D. Substation Enclosure Testing:

The following tests shall be performed after the installation of the substation on site:

1. Visual inspection for:

    a. Painting conformance

    b. Frame or metal deformation

    c. Access doors operation

    d. Locks and access

    e. Equipment movement

2. Verify equipment with bill of material.

3. Prior to conducting the rain test, provide the following:

   a. Drawing or sketches of the test set up in plan view and elevation.

   b. A narrative description of how the test will be conducted.

   c. Details of the water spraying apparatus, with sufficient information for the Engineer to verify compliance with the specified standard.

4. After the rain test, provide the test report with the following:

   a. Data recorded during the test

   b. Details of any leaks detected

   c. Steps taken after leak detection

E. Rectifiers Testing:

The following tests shall be performed after installation of the substation on site:

1. Insulation tests shall be performed between the diode strings and the rectifier enclosure using a 2,500 Vdc megohmmeter for 1 minute.

2. Insulation tests between the enclosure and ground shall be performed using a 2,500 Vdc ohmmeter for 1 minute.

3. Functional test of all temperature, protective, monitoring and alarm devices shall be performed.

F. Station Service Transformer Testing:

1. Insulation tests shall be performed between windings, and between all windings to ground, and between the core to ground using a 2,500 Vdc megohmmeter for 1 minute.

2. Transformer taps shall be adjusted for optimum ac secondary voltage.

G. Human Machine Interface (HMI) Panel Testing:

1. The control circuit functional test shall be performed by actuating control switches and observing the operation of the circuit breakers.

2. Alarm functions at the switchgear, transformer, and rectifier shall be simulated at each device and the correct indication verified at the HMI panel.

3. Correct operation of each test circuit, including all spare positions, shall be verified.

H. Fire Alarm and Intrusion Detection Testing: Correct operation of each test circuit, including all spare positions, shall be verified.

I. Auxiliary Systems Testing: Operational and functional tests shall be performed on all auxiliary systems including battery charger, panelboards including auxiliary contacts, utility instrument enclosure, door interlocks, and all systems provided in this Contract which are not specifically called out in this specification. The Contractor shall submit test procedures for each of these systems, including but not limited to the following:

1. Transfer trip

2. Emergency trip stations

3. Key interlock

J. Frame Fault Tests

1. The frame fault relay (Device 64) shall be connected as shown in the one-line diagram. An 800 Vdc to frame fault shall be simulated by passing various dc current levels through the relays. Graphical outputs including time-current characteristics shall be submitted on site at the time of the testing for review and approval. The maximum total clearing time including operation of the 64 Relay, the substation lock-out relay, the tripping of the main ac and dc feeder breakers shall not exceed 300 milliseconds.

2. In the event that certain test conditions do not conform to the test procedure, the contractor shall make necessary field adjustments, perform necessary calculations to demonstrate successful test completion. The calculation method shall be approved by VTA and included with the test report.

K. Negative Grounding Unit Tests

1. Negative to ground voltage tests shall be performed to demonstrate proper function of the negative grounding overvoltage relay (Device 159G) relay. Negative to ground voltages shall be simulated to show that the substation will trip when the voltage exceeds the threshold setting on the order of 50 V.

2. For each substation, the Contractor shall provide a 24-hour chart recording of the negative to ground voltages measured at the terminals of the dc switchgear during simulated or actual revenue service. Horizontal and vertical scale shall be set such that both time duration and magnitude of negative to ground

voltages are clearly readable. Resolution shall be no less than 100 milliseconds for time and 2 V for voltage.

3. The Contractor shall iteratively adjust the annunciation and trip setpoints until the optimum settings have been determined to the satisfaction of VTA. This process may require several weeks or more of monitoring and adjusting settings. The negative to ground settings shall be submitted to VTA for approval when all of the following conditions are met: 1) the annunciated setpoint is set 20 Vdc higher than the trip setpoint, and results in annunciated events without tripping out the substation; 2) the substation remains on line for 14 days without a nuisance trip including times when adjacent substations are removed from service for at least one hour 3) the recommended settings shall take safe touch and step potential into consideration.

4. For each substation, after the negative grounding overvoltage relay has been set and the settings accepted by VTA, the Contractor shall provide a 24 hour chart recording of the negative to ground voltages measured at the terminals of the dc switchgear for record and submitted for final approval. The horizontal scale shall be set so that both time duration and magnitude of rail-to-earth voltages are clearly readable. The recording shall be taken on a weekday, during actual or simulated revenue service, and shall become a part of the substation history book.

L. Cable Ground Test

1. Test dc cable with 1,000 Vac high potential for one minute between each positive and negative cable to ground. Leakage shall not exceed 2 mA. Test shall be conducted prior to cables being connected to rails and OCS.

M. SCADA

1. Test all SCADA points from initiating device to SCADA interface connection.

N. Battery and battery charge discharge Test

1. Full battery and battery charger discharge tests shall be performed after the substation equipment has been installed onsite.

O. Transfer Trip System

1. The transfer trip system shall be tested within each substation and between substations for correct operation of trip devices, and activation of appropriate circuit breakers.
2. Transfer trip by-pass operations shall be tested.

3.04 INTEGRATED SYSTEM TESTING

A. After installation and the completion and acceptance by VTA of the field tests, assist VTA in performing the integrated system testing described in this Section and as required by IEEE 1653.4-2011. Co-operate fully with VTA as required. Operate and maintain the Traction Electrification System (TES) until final acceptance by VTA. Correct any deficiencies found in the TES.

B. The Contractor shall perform a remote short circuit test and a local train start test. Each test shall be performed with a single substation online to establish maximum current from a single feeder. Contractor shall:

1. Verify that the rate of rise relay does not trip and the low level faults can be distinguished from starting train currents.

2. Adjust the relay settings and repeat tests as required.

3. Monitor and record all trains starting current and voltage data on oscillographs.

4. Include all the copies of test data in the test report.

5. Submit the test report and the final relay settings to VTA for review and approval.

C. The Contractor shall work with VTA to perform interface tests to confirm proper operation of all substation SCADA functions. The Contractor shall test each control and indication point controlled by the SCADA system and shall ensure that all appropriate indications are displayed and logged, and all appropriate control actions are granted.

D. Refer to 3.01 of Section 34 21 17 – HMI and SCADA Interface Requirements for SCADA/OCC end to end testing in each substation.

E. Short Circuit Tests

1. A dc short circuit test shall be performed with a bolted fault applied first to the load side of one dc breaker and then to the dc positive bus. These two tests shall verify proper calibration, function, and coordination of all protective devices and confirm adequate short-time capability of the dc circuit breakers.

2. The following additional bolted fault tests shall be performed with the OCS energized:

   a. Substation Tests: This test will be performed between two energized substations, selected by VTA, separated by a non-energized substation, selected by VTA, to establish the maximum energy interruption fault. Substations selected by VTA shall be energized and connected to the OCS. Bolted faults shall be applied to the OCS at 2,500 feet intervals from the substation under test to the substation beyond the non-energized middle substation resulting in a maximum distance between the two energized substations of approximately two miles.

b. Rate of Rise Substation Tests: Substations selected by VTA shall be energized one at a time and connected to the OCS. A bolted fault shall be applied in the immediate vicinity of the substations beyond the non-energized middle substation under test in both directions and will be seen as a bolted fault at the location the fault is applied and as a low level fault at the selected substation under test.

3. The ac circuit breaker, dc feeder breakers, and transformer secondary current shall be monitored simultaneously on a high-speed chart recorder during each short circuit application. In addition, each phase of the ac circuit breaker shall be monitored. Test results, including total inrush current, steady-state fault current, fault clearing time, primary system capacity, and operation of the load-measure/auto-reclose system, shall be recorded and submitted to VTA for approval.

4. All equipment shall be inspected for damage including loose bolts after each short-circuit test. Additionally, all breakers subjected to fault conditions shall subsequently be production tested in accordance with their applicable ANSI standards. If the transformer short circuit current exceeds the value recorded during the transformer design tests or the calculated value, the transformer shall be re-tested using the procedures for short circuit tests described in ANSI C57.12.91.

5. Any reconditioning required to return any component to original condition shall be at the Contractor's expense. Failure of the equipment to withstand these tests or to meet the performance levels specified shall be grounds for rejection of the equipment.

3.05 FINAL ACCEPTANCE

A. Prior to Final Acceptance of the work under this contract, Contractor shall have:

1. Submitted all as-built documents, drawings and disk files and obtained the approval of these items from VTA.

2. Successfully performed all required testing and reporting of test results.

3. Submitted all other deliverables including test equipment and tools, spare parts

as required by Specification 01 78 43 – Spare Parts, manuals, and training and obtained the approval of these items from VTA.

4. Resolved all open issues with VTA

END OF SECTION 34 21 63

SECTION 34 21 70

COMMUNICATIONS EQUIPMENT

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes furnishing and installing communications equipment and accessories for the Communications System as outlined herein.

1.02 REFERENCED STANDARDS

A. The following Codes, Regulations, Reference Standards, and Specifications apply to work included in this section:

1. ANSI/TIA/EIA-568-B, "Commercial Building Telecommunications Cabling Standard."
2. TIA/EIA 604-3-B, “Fiber Optic connector Intermateability Standard, Type SC”
3. ANSI/TIA/EIA-606-B, "Administration Standard for Telecommunications Infrastructure."
4. TIA/EIA-607-B, "Commercial Building Grounding and Bonding Requirements for Telecommunications."
5. IEEE 802.3, “Standard for Local Area Network (LAN) with Carrier Sense Multiple Access and Collision Detection (CSMA/CD) requirements”

1.03 SUBMITTALS

A. Products:

1. Performance data and descriptions of all products shall be submitted as part of the Preliminary Design Review submittal package. Additionally, product information shall include: manufacturer model number, UL listing or rating, critical dimensions and mounting arrangement, and replacement parts list as applicable to each product.
2. Samples of products shall be submitted upon request

1.04 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed thereafter.

1.05 QUALITY ASSURANCE

Refer to General Conditions GC-47, Quality Assurance Program for general requirements and procedures.

PART 2 PRODUCTS

2.01 FIBER OPTIC BREAKOUT BOX (FBB)

A. FBB shall be wall-mount type suitable for installation on enclosure back-panel and shall have a minimum capacity of terminating all strands of the fiber optic cables entering the panel.

B. FBB shall be provided with cable strain relief, cable routing guides and other accessories as required.

C. SC-type factory assembled and tested pigtailed connector adapter panels shall be provided with the FBB. Single mode and multimode pigtailed connector adapter panels shall be provided in quantities as required for terminating all strands of the cable plus at least one spare panel for future use. Adapters shall be of composite housing material and ceramic inserts. Adapter panels shall be available in various count or density options. FBB with fixed adapter panels shall not be acceptable.

D. Splice cassettes shall be provided for splicing the incoming cable into the adapter panel pigtails. Heat shrink protectors shall also be provided.

E. Caps shall be provided for all un-terminated fiber ports.

F. FBB Dimensions shall be as shown on Contract Drawings.

G. FBB panel shall be used to terminate single mode fiber optic cables as shown on the drawings.

H. Single mode FBB shall be provided at TPSS #33 and TPSS #34 as shown on Contract Drawings.

2.02 FIBER OPTIC CONNECTORS

A. Fiber patch cords shall have connectors compatible with the device's optical ports. SC type multimode and single mode connectors shall be provided for termination on the FBB. Connector shall be compatible with the fiber type.

B. Connectors shall be compliant with TIA/EIA-604-3-B Standard.

C. Connectors shall be high performance type with ceramic ferrule; typical insertion loss shall not be more than 0.1 dB

D. Non-epoxy non-polish type connectors shall be provided for fast and easy field installation.

E. Connector operating temperature shall be -40°F to 150°F or better

2.03 ETHERNET SWITCH

A. Rugged Industrial design in compliance with IEC-61850-3 and IEEE-1613 for substation environment.

B. The switch shall be in compliance with IEEE-802.1 and IEE-802.3 for wired Ethernet.

C. The switch shall have high availability, advanced Quality of Service (QoS), reliability and security features.

D. The switch shall have both copper and fiber ports for equipment and uplink connections. Equipment ports shall support 10/100BaseTX/poE, 100BaseFX and 100BaseLX. Uplink ports shall support 1G transmission rate on copper or fiber.

E. The switch shall be provided with single mode and multi-mode Small Form Ports (SFP) as required.

F. The switch shall be suitable for substation environment and shall comply with IEC

G. The switch input power shall accommodate ac and dc inputs; 125 VDC and 120 VAC.

2.04 TELEPHONE

A. Telephone shall be wall mount type, basic, VOIP, corded style 2554 and hearing aid compatible. One telephone each shall be provided at TPSS #33 and TPSS #34. All telephones shall be of the same color; beige, black or white are acceptable colors.

B. Telephone shall have the following features: one line, keypad pad on base or handset, volume control, redial and mute.

C. Telephone shall be provided with a mounting bracket suitable for surface mount.

D. Telephone shall not require power adapters to operate.

2.05 MISCELLANEOUS EQUIPMENT

A. Circuit Breakers and Fuses

1. Fuses and circuit breakers shall be of suitable capacities to protect the various pieces of apparatus from the effects of short circuits or overloads. All circuit breakers and fuses required for the equipment and systems shall be in accordance with these technical specifications.

2. Fuses shall be readily accessible, non-renewable and shall be permanently identified adjacent to the fuse. The rating of each fuse shall be permanently and clearly marked on each fuse. The circuit breakers and fuses shall be the correct size and rating for circuit current interruption and shall protect the electrical equipment and circuits from short-term and long-term overloads.

3. In DC branch circuits, where fusing is impractical, a protective resistance unit shall be furnished.

B. Tagging for Cables and Wires

1. Both ends of each cable shall be tagged where cables and wires terminate on terminals, punch-down blocks, connectors, etc. Communications cable identifiers shall comply with TIA/EIA-606-B.

2. Cable function, designation, and termination location shall be shown.

3. Sleeve type non-metal tags shall be used where cable diameter permits.

4. Flat plastic tags shall be used for other cables, as follows:

    a. A single hole in the tag shall be provided for attachment with a dielectric tie.

    b. Permanent lettering shall be used.

C. Tagging for Equipment

1. Label with unique identifiers, all terminal blocks, card cages, circuit cards, punch- down blocks, jack fields, etc. Communications equipment identifiers shall comply with TIA/EIA-606-B.

2. Permanent lettering scheme shall be utilized.

3. Labels shall be attached with a non-drying adhesive.

D. Internal Wire and Cable

1. Jacket: All internal wire and cable shall be classified and marked per NFPA 70 Article 800 for the intended installation classification.

2. Conductors: Conductors shall be soft annealed copper per ASTM B3.

3. Construction:

a. Single or multiple twisted pair cables shall have color coded insulation.

b. Cables shall be shielded where recommended by EIA standard for data rate, format, and distance.

E. Multi-pair Protected Terminal Blocks

1. Design: Protected terminal blocks shall be used at the input for all signal circuits using metal cable and entering/exiting the TPSS facility.

a. Multi-pair protected terminal blocks shall be utilized for applications requiring non-connectorized 25-pair or less terminal blocks.

b. Types and pair counts for terminal blocks shall be as shown on the approved drawings.

c. Terminal blocks shall consist of Bix Block type termination.

d. An external ground connector shall accept a 6 AWG ground wire.

F. Multi-pair Terminal Blocks (Non-protected)

1. Design:

a. Types and pair counts for terminal blocks shall be as shown on the approved drawings.

b. Terminal blocks shall consist of pairs of brass binding posts imbedded in high impact resistant polyurethane.

c. Binding posts shall be equipped with two brass nuts and washers. Binding posts shall be sized to accept a minimum of three #19 AWG conductors.

2.06 COMMUNICATION INTERFACE CABINETS (CIC)

Contractor shall furnish and install equipment cabinets. The cabinets shall be Hoffman, or approved equivalent, meeting the following requirements:

A. Be UL listed and meet the requirements of a NEMA 12 rating.

B. With minimum dimensions as shown in the Contract Drawings.

C. Screw down door clamps.

D. External wall-mounting brackets.

E. Be configured to receive station normal power.

F. Seams continuously welded and ground smooth.

G. Contain hard-drawn copper bus bar as shown in the Contract Drawings.

H. Meet additional grounding requirements located in Section 26 05 26 “Grounding and Bonding”

I. Have a 3/4-inch exterior grade plywood backboard, securely fastened to rear wall, and painted with fire-retardant paint.

J. Have a data pocket on the inside of the front door able to hold several 9" x 12" laminated sheets.

K. Be factory manufactured and assembled.

L. Be delivered ready for installation.

M Be secured on substation walls as shown in the Contract Drawings.

N. Be painted (including any cutouts) as follows:

1. Finish coated with 100% solid thermosetting polyester to a minimum 5-mil thickness.

2. Interior white color and exterior ANSI 61 gray.

O. Contractor shall provide all anchor bolts, u-channel and anchorage items as required and as shown in the Contract Drawings.

2.07 DC TO DC CONVERTERS

Contractor shall furnish and install DC to DC converters in communication equipment cabinets as shown in the Contract Drawings. DC to DC converters shall meet the following requirements:

A. UL Listed.

B. Input range of 100 VDC to 200 VDC,

C. Operating temperature range of -10 degrees C to +60 degrees C.

D. Meets FCC Class B, Part 15 requirements.

E. Output voltage of +24 VDC.

F. 100% power capacity reserve at full load.

G. High Efficiency of 75% to 85%.

2.08 WIRES AND CABLES

A. Data Cable:

1. ANSI TIA-232 Applications. Serial data cables used for RS-232 applications shall meet the following characteristics:

   a. Jacket: NEC CL2P, Low Smoke.

   b. Wires: Uniquely Color Coded.

   c. Cable Type: Twisted pair.

   d. Conductor gauge: #24 AWG (7 X #32 AWG) stranded, minimum.

e. Shield: 1 overall foil shield, with a braided shield minimum.

f. Capacitance: ≤40 pF/m (≤12 pF/ft).

g. Resistance: ≤100 Ω/km (≤30 Ω/1000 ft).

h. Conductors: 6 to 12 half- pairs.

2. EIA-422 and ANSI-530 Data Communications Cable. Serial data cables used for RS- 422 or RS-530 balanced electrical transmission of data shall meet the following characteristics:

a. Jacket: NEC CL2P, Low Smoke.

b. Wires: Uniquely Color Coded.

c. Cable Type: Twisted pair.

d. Conductor gauge: #24 AWG (7 x #32 AWG) stranded, minimum.

e. Shield: Individually foil shielded pairs each with a drain wire. One overall foil shield, with a braided shield minimum.

f. Capacitance: ≤43 pF/m (≤13 pF/ft).

g. Resistance: ≤30 ohms/1000 ft.

h. Characteristic Impedance: 100 ohms.

i. Conductors: 2 to 12 pairs.

B. UTP LAN Cable. All UTP connections used for local area network connections shall comply with Category 6 standards as defined in ANSI TIA-568-B.

C. Multi-pair Instrumentation Cable

1. 300 Volt power limited tray cables, Manufacturer Belden or approved equal.

2. UL-Listed.

3. 18 AWG twisted pairs, stranded tinned copper conductors.

4. Overall shield with 100% coverage.

5. PVC insulation and PVC jacket.

6. Nominal inductance:0.19 µH/ft.

7. Nominal capacitance conductor to shield: 95 pF/ft.

8. Nominal capacitance conductor to conductor: 42 pF/ft.

9. Nominal conductor DC resistance at 20° C: 6.8 Ω/1000 ft.

10. Nominal outer shield DC resistance at 20° C: 5 Ω/1000 ft.

D. Tight Buffer Indoor Fiber Optic Cable. Two strand tight buffer cables shall be used for interconnecting equipment and devices in different compartment inside the TPSS.

1. Cable Type Zipcord Tight-Buffered, 2-Strand

2. Cable Construction All die-electric, Flame Retardant, Non Corrosive

3. Fiber Categaory 62.5 µm Multimode

4. Minimum Bending Radius 45 mm Installation, 14 mm Operation

5. Maximum Attenuation 3.1 dB/km @ 850 nm, 0.8 dB/km @ 1300 nm

E. Fiber Optic Patch Cords. Duplex multi-mode and single mode fiber patch cords shall be used for connecting equipment in the same compartment. Patch cords shall factory assembled with connectors at both ends compatible with the device termination ports. Length of patch cord shall be determined based actual installation of equipment.

PART 3 EXECUTION

3.01 FBB

A. The Contractor shall install the FBB in accordance with Contract Specifications and Drawings and in compliance with manufacturer’s installation procedures. In addition, the Contractor shall take into consideration accessibility by maintenance and the possibility of future expansion when installing the FBB. The preferred location for the FBB at the TPSS replacements is inside the new CIC cabinets on the bottom half of the enclosure in order to avoid excessive tension on the cable. The FBB at these locations will be used for terminating fiber cables.

B. The Contractor shall provide all tools, hardware and testing equipment to properly prepare, install and terminate the fiber optic cable.

C. All splices shall be fusion type and protected with heat shrink sleeves. Mechanical splices are not acceptable.

D. Contractor shall use splice cassettes with the pigtailed adapter panel. The splice cassettes shall support fusion splicing with heat shrink, pigtails and cable slack management without interfering with other management.

E. All strands of the fiber optic cable shall be terminated on the FBB.

F. Cables shall be affixed with strain relief hardware so that there is no tension exerted on the terminations when the fiber optic cable is accidently pulled.

G. All fiber optic cables shall be identified to inform at a minimum the type of fiber, the number of strands and the destination of the cable.

H. All adapter panels shall be identified. Each port shall be assigned a number that corresponds to the number of the fiber cable strand.

I. Fiber optic patch cables terminating on the FBB side shall be provided with SC style connectors as described in these Specifications shall be provided.

F. The Contractor shall verify the core/clad of each the fiber cables and other characteristics and shall provide compatible equipment.

G. All FBB, cables and terminations shall be labeled as required elsewhere in these Specifications and as shown.

H. All fiber terminations shall be tested. Termination loss exceeding 1 dB at the FBB shall not be acceptable.

I. Testing of fiber optic cables and communications equipment shall be conducted by the Contractor and testing reports shall be provided as described elsewhere in these Specifications.

3.02 ETHERNET SWITCH

A. The new Ethernet switch shall be installed at TPSS #33 and #34 as shown on contract drawings and per the manufacturer's installation procedures.

B. The substation intelligent device modules shall connect to the switch as shown on the drawings with 2-strand multimode fiber interconnect cables. Multi-mode Small Form Pluggable (SFP) transceivers compatible with the fiber optic cable used shall be provided.

C. The switch shall connect to the PAC local area network via cat 6 cables having RJ-45 connectors at both ends as shown on contract drawings.

D. The switch shall have spare copper and fiber ports ready for terminating additional devices.

F. All terminations to the switch shall be labeled as required elsewhere in these Specifications.

G. The switch shall be tested, and test results shall be submitted as required elsewhere in these Specifications.

3.03 TELEPHONES

A. The Contractor shall install the telephones in accordance with Contract Specifications and Drawings and in compliance with manufacturer's installation procedures.

B. All cables and terminations shall be labeled as required elsewhere in these Specifications.

C. All telephones shall be tested. Test results shall be provided as described elsewhere in these Specifications.

3.04 TAGS

A. All tags shall be installed so that they are clearly legible in the normal position. Nomenclature on tags, as installed shall not read upside down.

B. All terminal block and apparatus tags shall be mounted such that removal of outside wiring from the unit shall not require or cause removal of the tag.

3.05 TERMINAL BLOCKS

A. All connections to terminal blocks shall be made in accordance with the approved connection details. Twisted pair jumper wire shall be utilized for cross-connections.

B. All wiring on terminal blocks shall be neatly bundled, and restrained to facilitate tracing wires by pulling.

C. Tags and labels shall be utilized to identify the terminal block designation and the pair number terminated on each terminal.

D. Protected terminal blocks shall be grounded with #6 AWG minimum ground wire.

E. All protector modules shall be tested prior to installation on terminal blocks.

3.06 COMMUNICATIONS INTERFACE CABINETS

A. The Contractor shall install communications interface cabinets in TPSS #33 and TPSS #34 as shown in the Contract Drawings.

B. The communications interface cabinets shall be installed plumb with respect to the walls and ceilings of the substation.

C. The communications interface cabinets shall be grounded with a minimum #6 AWG stranded copper cable.

D. The Contractor shall install the communications interface cabinets, conduits and associated equipment as shown in the Contract Drawings installation notes.

3.07 DC TO DC CONVERTERS

A. The Contractor shall install DC to DC converter in communications equipment cabinets as shown in the Contract Drawings.

3.08 WIRE AND CABLES

A. The Contractor shall install wires and cables in communications interface cabinets and traction power equipment as shown in the Contract Drawings.

B. All wires and cables shall be labeled.

3.09 FIBER OPTIC CABLES

A. All wires and cables shall be labeled.

3.10 FIELD QUALITY CONTROL

A. Quality: The quality of the Communications System installation shall be ensured through the performance of tests and inspections made during the progress of this Contract and after completing the installation of equipment. Perform field installation inspections to ensure that all equipment furnished under this Contract is installed in compliance with the technical specifications and workmanship standards and practices.

END OF SECTION 34 21 70

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SECTION 34 21 71

SCADA PROGRAMMABLE AUTOMATION CONTROLLERS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes requirements for the SCADA Programmable Automation Controllers (PACs) to be provided for the TPSS.

B. All PACs shall be new and shall be configured, programmed, and tested for performing all of the functions required for monitoring and controlling the electrification subsystem.

C. The PACs shall be configured to communicate with the Central Control System (CCS) over VTA's existing Local Area Network (LAN)

D. The new PACs shall be similar to Allen-Bradley Model 1756-A10/B. The Contractor may propose alternative equipment in accordance with the General Contractual Provisions. Any alternative equipment proposed shall be:

1. Consistent with Referenced Standards IEEE, C37.1 and C37.90.1, ISA RP55.1, IEEE 802.3 and UL 508.

2. Capable of performing functions as intended.

3. Modular with in design with processors and communications units power supplies and I/O modules residing on the same chassis

4. Scalable and expandable

5. Of an equipment family that have an installed base of at least 50 000 units.

6. Capable of communicating with third party equipment and processors.

7. Provided with equipment for programming and debugging.

8. Provided with comprehensive documentation of hardware and software operation and maintenance, programming and data communications protocols

1.02 REFERENCED STANDARDS

A. Institute of Electrical and Electronics Engineers, Inc. (IEEE):

1. C37.1 Standard Definition, Specification and Analysis of System Used for Supervisory Control, Data Acquisition and Automatic Control.

2. C37.90.1 Standard Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems.

3. 730 Standard for Software Quality Assurance Plans.

4. 730.1 Software Quality Assurance Plans.

5. 802.3 Standard for Local Area Network (LAN) with Carrier Sense Multiple Access and Collision Detection (CSMA/CD) requirements.

B. The International Society for Measurement and Control (ISA):

1. RP55.1 Hardware Testing of Digital Process Computers.

C. Underwriters Laboratories Inc. (UL):

1. 508 Industrial Control Equipment.

1.03 SUBMITTALS

A. Software Quality Assurance Plan.

1. Submit a Software Quality Assurance Plan for PAC software.

B. Software Requirements Specification.

1. The Contractor shall submit a PAC Software Requirement Specification (SRS), including description of the I/O logic and message-level interaction between the PAC and the CCS.

C. Design Information:

1. Conceptual Design Review: The Contractor shall submit the following information as part of the CDR: separate communication block diagram for each TPSS.

2. Preliminary Design Reviews:

a. The Contractor shall submit the following information as part of the Preliminary Hardware Design Review submittal:

1) Description of PAC configurations, with detailed block diagrams and I/O configurations for TES substations.

2) PAC components data sheets

3) PAC performance analysis using manufacture data or test data showing that the PACs meet the Response Time requirements developed in the Conceptual Design. Note that this analysis shall consider system poll time as part of the overall Response Time.

4) PAC equipment reliability analysis including the MTBF for typical Communications and TES substation PACs.

b. The Contractor shall submit the PAC Preliminary Software Design Review submittal package. This shall include:

1) Preliminary Software Design Description relevant to the integration of the new PAC’s to the existing SCADA system.

2) Preliminary version of the Device Interface Management Database. This version shall include a list of I/O points for each PAC.

3. Final Design Review information: The Contractor shall submit the following information:

a. As part of the Software Detailed Design Review submittal - Fully commented Ladder or Boolean based logic source code; description of memory layouts and register usage; software module design for software implemented in "C", “C++” or similar functional language; the Device Interface Management Database.

b. As part of the Hardware Final Design Review submittal – The Contractor shall submit bill of materials listings, communications block diagram for each PAC and I/O points assignment list.

D. As-Built Documentation: As part of the Communications System As-built documentation shall include:

1. For each PAC, drawings of all PAC equipment as located in cabinets, bill of material listing of all installed components, power cabling, data communications cabling and I/O wiring diagrams.

2. Final Ladder or Boolean based logic source code for each PAC; memory layouts and register usage for each PAC.

3. The Device Interface Management Database, including complete instructions on using and maintaining the database.

1.04 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed thereafter.

1.05 QUALITY CONTROL

Refer to General Conditions GC-47, Quality Assurance Program for general requirements and procedures.

1.06 QUALITY ASSURANCE

A. Software Quality Assurance: The Contractor shall plan, implement, administer, and maintain a comprehensive software quality assurance program, conforming to IEEE 730 and IEEE 730.1, for PAC software.

B. Emissions: PAC Test Sets and any other active devices shall comply with FCC emissions regulations for class A computing devices.

C. Device Interface Management Database: A device interface management database shall be developed and provided to the Resident Engineer. The database shall define each I/O point for each PAC. The precise path for all I/O points shall be identified on the database. For hardwired I/O points, the terminal block terminal of end and intermediate devices shall be identified. For soft I/O points being transferred between the PAC and processor-based field devices, the communication protocol and interface shall be identified. For each I/O point, the PAC file type, file number and the register's address shall also be listed on the database. The PAC identification number and the PAC IP address shall also be included. The database shall be verified during installation and test, and shall be provided to the Resident Engineer in electronic digital format and hardcopy format. Electronic digital data shall be either flat files, or database files of a commercially available relational database product which operates in the Windows environment to be agreed between the Resident Engineer and the Contractor.

D. For each TPSS, the Contractor shall compare the I/O list in these Specifications to the existing I/O database. Points that remain valid shall be mapped to the same file types and register addresses in order to not modify Dataset configurations associated with the database and to easily integrate the new PAC's to the existing SCADA system.

E. The Contractor shall adhere to the following standards:

1. IEEE C37.1
2. IEEE C37.90.1.
3. IEEE 802.3
4. ISA RP 55.1.
5. UL 508 and any additional applicable UL Standards.

PART 2 PRODUCTS

2.01 GENERAL

A. PAC Design Requirements:

1. The PAC shall be chassis-based modular family of controllers and I/O modules. It shall be capable of collecting field data and controlling field devices by hardwiring dry contacts, analog transmitters and relays to the I/O modules and by interfacing with other PAC's and processor-based field devices using widely used communications interfaces and protocols.

2. The PAC shall be solid-state electronic units of programmable design with stand- alone restarting capability. A real-time operating system necessary for the PAC to boot and establish communications with the CCS, store, load, compile, and execute program logic modules shall be resident in non-volatile memory.

3. The PAC processor shall have the following communications ports: two 10/100BaseTX Ethernet, USB, RS-232 and RS-485 ports. In addition, the PAC shall also come with a built-in VGA and HDMI ports. The Ethernet port shall provide program upload, download and editing capabilities as well as communications with the CCS using the existing LAN/WAN service.

4. A power failure restart indication shall be reported to the CCS after recovery from a power failure so that any necessary initializing and down-loading may be initiated by the CCS.

5. The PAC operating system shall be Windows CE 5.0, or the latest version approved by VTA, capable of running PC- based control software and have features such as fast boot, interrupt handling and hard real-time capabilities. The operating system shall support embedded services such as FTP server, Web server and SQL server.

6. The processor shall have built-in flash disk, random access memory (RAM) of 128 MB and read only memory (ROM) of 16 KB minimum.

7. In conjunction with the other PAC logic elements, the following functions shall be configured:

   a. Respond to commands locally and remotely from the CCS for retrieving data.

   b. Provide an acknowledge sequence for relay control commands. After a point is selected, a check shall be made and an acknowledge message shall be returned to the CCS. Acknowledgment of receipt and activation of the relay execute command shall be determined by the action of the point under control.

   c. Prevent selection of more than one control point in a command sequence by:

      1) Inhibiting relays from inadvertently being energized during the initial power up period of the logic, as a result of failed communication, or any other anomaly.

      2) Protecting against a missing or failed logic card or assembly from causing an invalid operation, damage to other logic, or false transmission to the CCS.

      3) Protecting against power source over/under voltage conditions causing an invalid operation, damage to logic, or false transmissions to the CCS.

7. The PAC shall be provided with a spare capacity of at least 25% of wired I/O points.

B. Environmental: All PACs shall operate continuously with specified performance and without reduction in equipment life under the conditions specified in Section 26 00 01, "Basic Electrical Materials and Methods."

2.02 PAC COMMUNICATIONS INTERFACE

A. The PAC shall communicate using the LAN Ethernet ports. A media converter as applicable shall be provided at the TPSS to convert to 10BASE F for transmission to the SCS. Refer to Specifications Section 34 21 70 “Communications Equipment” and Contract Drawings for more details.

B. PAC Communication Logic:

1. The PAC communication logic shall perform the following functions:

a. Error-check encode and decode.

b. Decoding and processing of incoming messages.

c. Assembling reply messages.

d. Acknowledgement (i.e., resend/don’t resend message).

2. The PAC protocol shall be TCP/IP compatible with the Station LAN and CCS.

3. The PAC shall contain an SNMP agent necessary for the LAN manager to perform all required performance monitoring, configuration control and diagnostics. The agent shall include all available manufacturer’s MIBs which report the operating state or allow the remote configuration of the PAC equipment.

2.03 PAC COMPONENTS

A. The PACs and associated equipment must be comprised of the following:

1. Chassis: Allen-Bradley Model 1756-A10/B chassis, or larger as required to provide space for the necessary modules and future expansion, or equal

2. Power Supply: Allen-Bradley Model 1756-PA75R/A redundant power supply or equal

3. Controllers: Allen-Bradley ControlLogix 1756-L73 controller or equal

4. Ethernet Adapter Modules: Allen-Bradley Model 1756-EN2T Communications

Interface Module or equal

5. I/O Modules:

   a. Digital Input Modules: Allen-Bradley Model 1756-IB16IF or equal

   b. Digital Output Modules: Allen-Bradley Model 1756-OB16IEF or equal

2.04 PAC PROGRAMMING AND TEST SET

A. The PAC shall be provided fully configured and loaded with the TPSS specific application program. The programming software shall be ICP DAS IsaGraf.

B. The Contractor shall provide a test set which includes a laptop, cables, connectors and testing documentations. The laptop operating system shall be MS Windows based system, configured for communicating with the PAC. All cables used for testing purposes shall be readily prepared with compatible connectors.

C. Configuration for PAC Test Set Software: The Contractor shall provide test set software with the following functions:

1. Simulation of the CCS messages to a PAC.

2. Simulation of PAC messages to the CCS.

3. Ability to capture and view the transmitted or received messages.

4. Ability to control the bit patterns of messages initiated from the Test Set. This shall include the capability of forcing errors.

5. Selection of continuous and manual initiation of transmission.

6. Ability to access the PAC data base, examine/modify the data base parameters, and run calibration and diagnostic routines.

D. Communications: Each test set shall include communications ports and cables compatible with those of the Contractor furnished PACs and the existing Allen-Bradley PACs.

2.05 MAINTAINABILITY

A. Maintenance Safety: PAC equipment shall be designed, configured, and installed to optimize the safety of maintenance personnel.

B. Self-Tests: PACs shall perform self-tests upon power on, upon command from the CCS and upon local command through Test Set or local control panel. Self-tests shall include:

1. PAC main processor subsystem operation, including ROM checksum, RAM check, timer checks, and system bus check.

2. I/O subsystem and I/O card checks.

3. Data communications interface check.

C. Fault Detection and Reporting: Faults shall be indicated to the Field Replaceable Unit level:

1. I/O card faults shall be indicated on an LED on the card, and shall be reported to the CCS. Upon introduction of replacement cards, the PAC shall report to the CCS.

2. I/O subsystem faults shall be indicated on an LED, and shall be reported to the CCS.

3. The PAC shall indicate locally the status of its ability to communicate over the LAN and the local communication bus.

4. The PAC shall indicate the presence of operating power locally.

5. The PAC shall report a restart condition to the CCS equipment after power on and after return to operation following a power failure.

D. Equipment Replacement:

1. PACs shall provide a safe means for maintenance personnel to disable power to input/output circuits. The power-disabled state shall be indicated locally.

2. The PAC shall provide for safe I/O card replacement. Upon replacement and power-up, card self-tests shall automatically be initiated. Self-testing shall include verification that the I/O configuration of the replaced card

matches the previous I/O configuration.

2.06 DESIGN AND CONFIGURATION MANAGEMENT SOFTWARE

A. The configuration management software shall be compatible with ICP DAS WinPAC platform and Microsoft Windows based operating system. The software shall provide configuration management services for Ethernet/IP network.

PART 3 EXECUTION

3.01 PAC PROGRAMMING AND CONFIGURATION

A. Programming and configuration of the PACs shall conform to the final approved Design Review Submittal and resolutions addressed during the design submittal phase.

3.02 FACTORY TESTS

A. The Contractor shall simulate field condition at his own facility to prove full operation and functionality of the PAC's prior to shipment at the site.

B. Each point on the Installed I/O cards shall be tested and verified against the controller's data files.

C. The soft I/O points between field devices and the PAC shall be simulated to prove that data can be received and transmitted over the communication bus.

D. PAC Data Communications: The Contractor shall perform tests to verify the data communications message formats and protocol, including all I/O bit assignments, for all PACs using the location specific hardware and software.

3.03 INSTALLATION - GENERAL

A. The Contractor shall provide and install:

1. Each PAC in a specific cabinet. The PAC shall be wired to field contacts and relays and shall be interfaced with the media converter and Ethernet switch. All terminations shall be labeled as required elsewhere in these Specifications. Reference Specifications Section 34 21 70 "Communications equipment" For detailed requirement.

3.04 PAC INSTALLATION AND TEST

A. Installation Test Procedures: Installation and test of PAC equipment shall be conducted according to the approved Installation Plan and Field Test Procedures. PAC installation shall not commence prior to Resident Engineer approval of the Installation Plan for the corresponding type of PAC installation.

B. Installation of PAC Equipment: Installation of PAC equipment shall include the following activities:

1. Pre-installation inspection of available space, power, grounding system, cable and conduit runs, device interfaces, and wire terminations performed by others.

2. Confirmation of the physical inventory data and pre-installation visual inspection of PAC equipment.

3. Post installation inspection of all equipment, mounting, cabling, and wiring.

C. Testing of Installed PACs: Records shall be maintained for all PAC installation and test activities, and shall be delivered to the Resident Engineer. Tests shall include as a minimum:

1. Equipment diagnostics.

2. Data communications testing simulated between the PAC and the CCS.

3. Signal testing for indication input at the PAC terminal block.

4. Signal testing for control outputs at the PAC terminal block.

5. Data communication testing between the PAC communications module and field devices.

6. Device and alarm testing using the Test Set and verification of the associated Device Interface Management Database.

3.05 FIELD QUALITY CONTROL

A. Quality: The quality of the Communications System installation shall be ensured through the performance of tests and inspections made during the progress of this Contract and after completing the installation of equipment. Perform field installation inspections to ensure that all equipment furnished under this Contract is installed in compliance with the technical specifications and workmanship standards and practices.

END OF SECTION 34 21 71

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SECTION 34 21 90

TRACTION POWER TRAINING

PART 1 – GENERAL

1.01 SUMMARY

A. The Work of this Section includes the requirements for instruction and training of VTA Operations and Maintenance (O&M) personnel in the operation and maintenance of all installed equipment and systems.

B. The Work also includes provision of classroom(s), training aids and on-site instruction as most appropriate for the particular equipment or system or as specified in the Contract Documents.

C. The training courses shall utilize the approved O&M manuals in conjunction with the training aids, manuals and so forth, as specified in these Specifications.

1.02 REFERENCED STANDARDS

A. None

1.03 SUBMITTALS

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

B. The training course outline shall include, but not be limited to, a complete list of all training modules, duration of each module, module objectives, and the instructor's resume.

C. Training program outline and schedule.

D. Training Session I.

E. Training Session II.

F. Training Session III.

G. Outlines for User Education Training Classes.

H. Training Materials.

I. Trainer Résumés.

J. Submit a training course outline and training manuals for all products, equipment, and systems specified on the Contract Documents.

K. The training manuals shall include all materials that will be presented during the training courses.

L. Provide DVDs containing the entire initial training course.

1.04 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed thereafter.

1.05 TRAINING COURSES

A. Conduct training courses 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 courses shall enable a qualified service technician to operate, troubleshoot, and maintain the equipment and systems. Training programs shall be specific to the products and design of the system implemented.

B. Contents of the courses shall include descriptions of procedures and in-service training or simulation for placing the substation into initial operation, making necessary adjustments while the equipment is in operation, and shutting down the equipment. The course shall also include troubleshooting procedures and thorough instructions in emergency procedures. The course shall prepare the trainee for competent operation of equipment.

C. Contents of the courses shall also include the basics of safety and electrical equipment maintenance, and classroom description and in-service training in the performance of testing, maintenance, troubleshooting, adjusting, disassembling, and assembling of all furnished items. The course shall prepare the trainee for competent maintenance of equipment.

D. Training Materials – All printed training materials or audio-visual aids prepared as training aids shall become the unrestricted property of VTA upon completion of the training program at no additional compensation.

E. The training courses shall include, but not be limited to, the following topics:

1. Site O&M manual and design documentation familiarization
2. Equipment operations
3. Equipment maintenance
4. Assembling and disassembling of assemblies, sub-assemblies and components
5. Servicing
6. Preventive maintenance
7. Repairs
8. Safety/emergency procedures
9. Trouble shooting

F. Training shall include hands-on training at one or more of the new TPSS. This hands-on training shall familiarize trainees with the location of all equipment and operations and maintenance practices. Safety shall be emphasized during this training module.

G. Upon successful completion of the training courses, VTA trained personnel shall receive certification to operate and maintain the equipment.

H. Schedule the training courses through VTA. Formal notification of the training courses shall be given to VTA as indicated in Section 01 33 00, Submittal Procedures.

I. All training courses shall be completed prior to the date of substantial completion.

1.06 TRAINING MANUALS AND TRAINING AIDS

A. Training manuals shall be provided in electronic format (MS Office) on a CD or DVD-ROM.

B. Provide each VTA O&M staff member with one copy of pertinent training manuals and pertinent O&M manuals before the start of training courses. Provide VTA with two additional training manuals for file and reference documents.

C. Provide all special tools, equipment, training aids, and other materials required for the training of VTA personnel. The number of special tools and other training equipment shall be adequate for the number of participants attending the training courses.

D. All printed, audio, and video training material used during the course of the training shall become the unrestricted property of VTA.

E. VTA reserves the right to copy all training manuals and training aids for use in VTA-conducted training courses.

PART 2 – PRODUCTS – (NOT USED)

PART 3 – EXECUTION

3.01 GENERAL TRAINING REQUIREMENTS

A. Provide training courses for VTA's personnel in the operation and maintenance of products, equipment, and systems.

B. Provide 3 training sessions for VTA's personnel.

1. Session I Training shall be provided for VTA's First Shift personnel between the hours of 06:30 and 14:30.
2. Session II Training shall be provided for VTA's Second Shift personnel between the hours of 14:00 and 22:30.
3. Session III Training shall be provided for VTA's Third Shift personnel between the hours of 22:00 and 06:30.

END OF SECTION 34 21 90

SECTION 34 23 00

GENERAL REQUIREMENTS FOR OVERHEAD CONTACT SYSTEM

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes General Requirements of the Overhead Contact System (OCS) for the VTA Eastridge to BART Regional Connect: Capitol Expressway Light Rail Project. Work includes, but not limited to:

1. Detailed Engineering design of complete OCS for the aforementioned project.
2. Detailed Engineering design of addition of parallel aerial feeder cables between Traction Power Substations #27 and #28.
3. Procurement, delivery, installation, and testing of OCS, from interface with traction power substation feeder breakers to interface with light rail vehicle pantograph.
4. Development of detailed construction staging schedules to allow VTA to maintain light rail service.
5. Integrated testing in accordance with Contract Documents.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work.

1. Section 26 41 23.16 – DC Surge Arresters
2. Section 34 23 13 – Overhead Contact System Metal Poles
3. Section 34 23 15 – Overhead Contact System Pole and Guy Anchor Foundations
4. Section 34 23 16 – Overhead Contact System DC Insulated Power Cables
5. Section 34 23 19 – OCS Pole Mounted Disconnect Switch
6. Section 34 23 22 – Overhead Contact System Kevlar Rope
7. Section 34 23 23 – Overhead Contact System Bare Conductors
8. Section 34 23 26 – Special Tools
9. Section 34 23 33 – Galvanized Steel Wire and Wire Rope
10. Section 34 23 36 – Stainless Steel Wire Rope
11. Section 34 23 39 – Overhead Contact System Assemblies, Components, and Fittings

12. Section 34 23 43 – Fasteners
13. Section 34 23 46 – Section Insulators
14. Section 34 23 49 – Insulators
15. Section 34 23 53 – Overhead Contact System Installation
16. Section 34 23 69 – OCS and TES Interface Testing and Commissioning

1.02 REFERENCED STANDARDS

A. American Railway Engineering and Maintenance-of-Way Association (AREMA)

1. AREMA (Chapter 9 – Railway Electrification).

1.03 SUBMITTALS

A. Refer to Special Conditions for Submittal requirements and procedures.

B. For all submitted drawings:

1. Include Table of Contents.
2. Bind in one 11 by 17-inch volume.
3. Package shall bear the seal of a Professional Engineer registered in the State of California, qualified by experience, who personally supervised the preparation of the Contractor’s OCS submittals.

C. Submit OCS detailed information for the following:

1. Calculations shall include but not be limited to:
   a) Hanger calculations including those for overlap and out-of-running spans.
   b) Cantilever, headspans, counterweight assembly and jumpers construction dimensions.
2. Shop Drawings in accordance with Section 34 23 39 “Overhead Contact System Assemblies, Components, and Fittings.”
3. Shop Drawings – shall show details of all OCS Assemblies required in the Work, including load ratings, dimensions, weight, and installation instructions, including torque value/requirements. Each shop drawing shall have a bill of materials listing all components and include their part of catalog number, descriptive text, quantity required, and unit of measure. Shop drawings shall be provided for all assemblies including, but not limited to:
   a) Anchor brackets.
   b) Feeder assemblies.

c) Down guy assemblies.

d) Cantilevers.

e) Section insulators.

f) Contact bridge.

g) Jumpers, knuckles, and cross contacts.

h) Hangers.

i) Surge arresters.

j) Counter weight anchors.

k) Fixed terminations.

l) Headspans.

m) Feeding, disconnect, and bypass disconnect switches.

n) Parallel feeder cable support assemblies.

1.04 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section be considered as included in the bid items in Section 34 23 53 "Overhead Contact System Installation," and no additional compensation will be allowed therefore.

PART 2 – PRODUCTS

2.01 OCS DESIGN CRITERIA

A. System Type.

1. SCAT – Simple Catenary Auto Tensioned.

a) Location: Install on the proposed extension from Alum Rock Light Rail Station to the end of storage tracks adjacent to Eastridge Shopping Mall, approximately 2.4 miles.

b) Configuration: Single 350 kcmil contact wire, suspended from a 500 kcmil messenger wire by hangers.

c) Tensioning: Conductors are tensioned with a counter weight at opposite anchors with a midpoint anchor at approximately mid-span of the tension lengths. Conductors are also tensioned with counter weight and fixed termination at opposite ends of the half tension lengths. Tension conductors according to charts provided in the Contract drawings.

d) System height: SCAT shall maintain a normal system height of 4.5 feet.

e) Supports: OCS poles installed at-grade, on aerial guideway, or station mounted supports.

2. Parallel Aerial Feeders

a) Location:

i. Install on the proposed extension from Alum Rock Light Rail Station to just north of the diamond crossover, north of the proposed Eastridge Station.

ii. Install along the existing alignment between existing Traction Power Substations #27 and #28.

b) Configuration: Single 1000 kcmil bare aluminum (AAC/TW) conductor.

c) Tensioning: Conductors are tensioned with fixed terminations at opposite anchors. Tension conductors according to charts provided in the Contract drawings.

d) Height: Conductors shall be installed 4 feet above messenger wire, unless noted otherwise in the Contract drawings.

e) Supports:

i. Along the proposed Extension: OCS poles installed at-grade and on aerial guideway.

ii. Along Existing Alignment (#27-#28): Pole extensions mounted on top of existing OCS poles.

B. OCS Voltage: Nominal 750 Vdc.

C. Conductor Temperatures.

1. Open Route.

a) Maximum Loading: 20 degrees F

b) Normal Loading: 60 degrees F

c) Minimum Loading: 130 degrees F

D. Ice Loading.

1. Open Route.

a) Not Applicable

E. Wind Loading.

1. Open Route.

a) Maximum wind speed for structural design: 71 mph

b) Maximum wind speed for train operations: 55mph

F. Electrical Clearances.

1. Minimum Static Clearance: 4 inches

2. Minimum Passing Clearance: 3 inches

3. Erected supports, brackets, cables, and other installed equipment shall comply with the LRV and pantograph clearance requirements as indicated in the Contract Drawings.

G. Minimum Contact Wire Heights (as referenced to top of high rail level of individual tracks at a specified support location).

1. Exclusive right-of-way, at grade: 18 feet, 0 inches

2. Exclusive right-of-way, on aerial guideway: 15 feet, 0 inches

H. Safety Factors.

1. Design OCS with the following minimum safety factors under specified temperature loadings.

a)	Overhead Conductors: (Contact wire worn to 80% of original area)	2.00
b)	Line Insulators	2.00
c)	Guy Insulators	2.00
d)	Metal Cantilever Assemblies	1.25
e)	TES Poles	1.50
f)	TES Pole Foundation (When designing against overturning)	1.50

I. Contact Wire Gradients (rate at which the contact wire changes elevation relative to track) per AREMA recommendations:

1. Constant Gradient:

	LRV Speed Range	Maximum Gradient
a)	1 to 15 mph	2.3 percent
b)	16 to 30 mph	1.3 percent
c)	31 to 45 mph	0.8 percent
d)	46 to 60 mph	0.6 percent

2. Change of Contact Wire Gradient:

    a) The maximum change in contact wire gradient shall be equal to one-half (0.5) the maximum gradient from one (1) span to the next.

J. Pantograph Clearance Envelope.

1. Minimum pantograph security (mechanical clearance): 3 inches

2. Maximum pantograph uplift allowance: 3 inches

3. Minimum electrical clearance to swayed pantograph: 3 inches

4. Minimum pantograph wear: 1 inch

K. Permissible Mid-span Offset.

1. Maximum: In accordance with Contract Drawings.

2. Installation Tolerance: 1 inch

L. Contact Wire Radial Loads.

1. Contact wire loads shall be in accordance with Contract Drawing.

M. Heal Settings.

1. Calculate steady arm heel settings, the vertical distance from the contact wire level to the swivel point of the steady arm, as a resistant of the vertical and radial loads present at each registration point.

2. Show heel setting values on the shop drawings where applicable.

3. Minimum steady arm heel setting: 1 inch

4. Install heel point of steady arm outside horizontal limits of the pantograph clearance envelope.

N. Span Length Tolerances.

1. Pole foundations constructed shall have the following dimensional erection tolerances applied relative to the Contract documents, as approved by VTA.

    a) Foundation offset from track centerline: 1 inch

    b) Stationing along track centerline near curved or special track work: 2 feet

    c) Stationing along track centerline on tangent track: 5 feet

    d) Span length change between adjacent pole foundations: 5 feet

2. Where foundation relocation is necessary but would fall outside the limits given above,

apply to Resident engineer for instructions.

O. Electrical Insulation.

1. Provide minimum of two levels of electrical insulation between an energized bare wire and a grounded structure.

   a) Provide one insulation at contact wire/messenger wire registration support.

   b) Provide second level of insulation adjacent to the structure.

2. At terminations of energized wires, provide two strain insulators separated by a minimum distance as indicated in the contract drawings.

3. Rate each level of insulation so as to be compatible with the system insulation class.

4. Headspans shall be double insulated.

P. Aesthetics shall be considered when determining assemblies and components in passenger stations. Assemblies and components must be low profile, and well blended to immediate surrounding structures in order to minimize the visual impact in passenger stations.

PART 3 – EXECUTION

Not Used

END OF SECTION 34 23 00

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SECTION 34 23 13

OVERHEAD CONTACT SYSTEM METAL POLES

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for the design, fabrication, furnishing, delivery, installations and testing of metal poles (including pole extensions). The work shall also include the removal of existing poles as shown on the Plans.

B. Fasteners for steel poles shall conform to the applicable requirements of Section 34 23 43, “Fasteners.”

C. Installation of the other components of the Overhead Contact System is specified under Section 34 23 53, “Overhead Contact System Installation,” and under applicable sections of Division 26, “Electrical.”

D. New poles, caps, and base covers, as identified in the Contract Drawings, shall be painted as defined in this section.

1.02 REFERENCED STANDARDS

A. American Institute of Steel Construction (AISC):

1. S302 — Code of Standard Practice for Steel Buildings and Bridges

2. S335 — Specification for Structural Steel Buildings; Allowable Stress Design and Plastic Design, with Commentary

B. American Society for Testing and Materials (ASTM):

1. A36/A36M — Standard Specification for Carbon Structural Steel

2. A53/A53M — Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinz-Coated, Welded and Seamless

3. A123/A123M — Standard Specifications for Zinc (Hot-Dip Galvanized) Coating on Iron and Steel Products

4. A143 — Standard Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement

5. A153/A153M — Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

6. A283/A283M — Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates

7.	A307	Standard Specifications for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength
8.	A384	Standard Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies
9.	A563	Standard Specification for Carbon and Alloy Steel Nuts
10.	A572/A572M	Standard Specification for High Strength Low-Alloy Columbium-Vanadium, Structural Steel
11.	A595	Standard Specification for Steel Tubes, Low-Carbon, Tapered for Structural Use
12.	B6	Standard Specification for Zinc
13.	E709	Standard Guide for Magnetic Particle Examination
14.	F436	Standard Specification for Hardened Steel Washers
15.	F593	Standard Specification for Stainless Steel Bolts, Hex Cap Screws and Studs

C. American Welding Society (AWS):

1.	D1.1	Structural Welding Code – Steel

D. Department of Defense Specifications (DOD):

1.	P-21035	Paint, High Zinc Dust Content, Galvanizing Repair

E. Related Specifications:

1.	Section 05 05 13	Shop Applied Coatings for Metal
2.	Section 05 05 60	Welding
3.	Section 34 23 53	Overhead Contact System Installation

1.03 SUBMITTALS

A. Design Calculations: Within 45 days of receiving contract award. Contractor shall submit for review calculations for the design of tubular poles as indicated in Article 2.01 herein. Calculations to be signed and sealed by a civil or structural engineer registered in the State of California.

B. Shop Drawings: Within 45 days of receiving contract award, Contractor shall submit shop drawings for review giving complete information necessary for fabrication of the poles. The shop drawings shall be to scale and shall indicate all fittings, holes and accessories, and the locations, sizes and types of all welds. Six black line copies of each shop drawing shall be submitted. In addition, 1 reproducible shall be submitted for all documents larger than 11 x 17.

C. Welding: Within 45 days of receiving contact award, Contractor shall submit for acceptance:

1. Specifications for welding procedures in accordance with AWS D1.1.

2. Certificates of qualifications of welders, welding operators and tackers in accordance with AWS D1.1.

3. Certificate of qualifications of welding inspectors in accordance with AWS D1.1.

D. Proofs of Compliance: Before commencing fabrication, Contractor shall submit for review the manufacturer's certificates of compliance, or certified laboratory test reports demonstrating the compliance of all raw materials and fabricated products with Article 2.02, "Materials," of this Section. Included shall be a listing of the ASTM standards designated by the manufacturer, as indicated. Method of paint application, material specifications, and a sample of finished application of the proposed color shall be included in these submittals.

E. Test Reports: 6 copies of certified laboratory test reports shall be submitted within 5 days of each test, or series of tests, in accordance with the requirements of Article 1.05, "Pole Testing and Inspection," of this Section

F. Pole Deflection Test Procedures: Contractor shall submit to VTA, in writing, a test procedure for approval, before testing any poles. The test procedure shall include method of application of loads, recording devices, calibration of devices and any other information deemed pertinent by VTA. Parameters demonstrated shall include load at maximum deflection, and deflection at maximum loading.

1.04 QUALITY CONTROL

A. Materials and components manufactured to applicable foreign standards, including metric standards, are acceptable, provided that Contractor submits written evidence, in the English language, that they are equal or superior to those complying with the standards listed in Article 1.02, "Reference Standards," and that written approval is obtained from VTA.

B. Contractor shall perform the following:

1. Material qualification testing and certification for acceptance of materials, components and assemblies.

2. Job control testing of in-progress work being performed in shops, factories and on-site.

3. On-site inspection of specified work elements.

C. Quality assurance shall be in accordance with the provisions of Special Conditions, Section 6.26 “Quality Assurance and Quality Control Requirements.”

1.05 POLE TESTING AND INSPECTION

A. Material Testing: Determine the chemical compositions and appropriate properties of all materials proposed either by obtaining manufacturer's certificates of compliance or by laboratory testing at a facility acceptable to VTA.

B. Weld Testing:

1. The services of an AWS certified welding inspector shall be provided by the pole fabricator:

    a. Inspect fabrication operations.

    b. Inspect welding procedures.

    c. Inspect welding personnel.

    d. Perform Ultrasonic and magnetic particle testing.

2. A visual inspection of all welds shall be performed in accordance with AWS D1.1.

3. Weld testing shall be performed on all poles and shall be tested by the ultrasonic and magnetic particle methods.

4. Equipment, procedures and personnel for weld testing, and test reports, shall conform to the requirements of AWS D1.1, Section 6, "Inspection."

5. Weld testing shall consist of:

    a. Ultrasonic testing conforming to the requirements of AWS D1.1, Section 6.

    b. Magnetic particle testing conforming to the requirements of ASTM E709.

6. Ultrasonic testing shall be performed on the complete penetration welds between the pole shaft and pole base, and on any circumferential welds in the pole shaft. Magnetic particle testing shall be performed on all other welds including longitudinal seam welds and welds at handholes, cable outlets, and other welded on attachments and reinforcements.

7. Results of weld testing shall be deemed acceptable or unacceptable in accordance with AWS D1.1, Section 8, 9, or 10.

8. Welds found to be unacceptable shall be repaired in accordance with AWS D1.1, Section 5, "Fabrication," and re-tested.

C. Galvanizing Testing:

1. ASTM A123/A123M or ASTM A153/A153M: Galvanizing Compliance.

2. ASTM A143: Embrittlement.

3. ASTM A348: Distortion.

D. Pole Deflection Testing: Contractor shall demonstrate to VTA, the deflection of all pole types procured under this Contract. The demonstration shall be in the form of a factory test, performed at the place of the manufacturer. The testing shall be non-destructive and at a place and time agreed by VTA. The test shall be conducted on a rigid foundation that resists all translation and rotation in any axis. Refer to Article 1.04 entitled "Submittals" herein for additional requirements. The cost of this testing, any required re-testing, and the issue of test reports shall be included in the bid price, and no additional compensation will be paid to Contractor.

E. Inspections: Provisions shall be made for inspection of the fabrication and testing by VTA or its authorized representative. Contractor shall obtain 2 weeks advance notice from the pole manufacturer. This inspection will be at the expense of Contractor. Inspection by VTA at the point of manufacture will not constitute acceptance of the work as specified.

1.06 PRODUCT DELIVERY, STORAGE AND HANDLING

A. During fabrication and delivery, the poles shall be handled and transported in a manner to preclude damage to either the structural steel paint surface or the zinc coating.

B. Damage to the material and equipment shall be Contractor’s responsibility and all repairs shall be accomplished by the Contractor in accordance with the manufacturer's instructions, at Contractor's expense.

C. Poles shall be delivered complete with associated fittings and accessories, properly packed and protected against damage and loss of parts, and protected from damage during storage and handling, and during moving from the storage facility to the installation sites.

D. Material shall not be stored in contact with the ground. It shall be stored in a manner and location that will not cause its deterioration.

E. Poles shall be delivered to site at a rate and in a manner, that will ensure uninterrupted work.

F. Existing poles to be removed shall be handled with care in for reuse by the VTA. They shall be delivered to and unloaded at a site to be identified by VTA.

1.07 MEASUREMENT AND PAYMENT

A. Measurement: Metal Poles shall be measured by the unit price (EA).

B. Payment:

1. OCS Poles (Tapered): The contract price paid per unit price (EA) for OCS Poles shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing OCS Poles complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

2. OCS Feeder Poles (Tapered): The contract price paid per unit price (EA) for OCS Feeder Poles shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing OCS Feeder Poles complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

3. OCS Counterweight Poles (Tubular): The contract price paid per unit price (EA) for OCS Counterweight Poles shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing OCS Counterweight Poles complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

4. OCS Pole Extensions: The contract price paid per unit price (EA) for OCS Pole Extensions shall include full compensation for furnishing all labor, materials, tools, equipment and

incidentals, and for doing all Work involved in constructing OCS Pole Extensions complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 DESIGN

A. VTA LRT Standard Detail Manual or the Contract Plans show specific pole designs, based on the materials, sizes, and fabrication methods specified herein. Contractor may, at his option, modify these designs to use different materials, details, and fabrication methods, subject to acceptance by VTA, provided that poles built to the modified designs have a performance equal to, or exceeding, those specified herein. All designs are subject to full aesthetic review and must be accompanied by complete design calculations, and by full information on the materials, standards, and details used, and the proposed methods of fabrication. Any modified designs shall conform to the following requirements:

1. Pole Design: Pole design shall conform to AISC S302 and AISC S335, and shall satisfy the strength and deflection criteria specified in Articles 2.01.A.3 and 2.01.A.4 of this Section, using the materials specified in Article 2.02. Pole sizes, including diameter and taper, shall be as shown on the Plans.

2. Pole Extension Design: Design shall conform to AISC S302 and AISC S335, and shall satisfy the strength and deflection criteria specified in Articles 2.01.A.3 and 2.01.A.4 of this Section, using the materials specified in Article 2.02. Pole sizes, including diameter and taper, shall be as shown on the Plans. The slip joint overlap for tapered poles, where no boxbolts are utilized, shall be dimensioned such that the overlap length is at least 1.65 times the outside diameter of the pole extension base.

3. Pole Strength: Poles shall be designed by the working stress method of the AISC S302 and AISC S335, using the design working moment (M) shown on the Contract Plans. The allowance for a 0.33 increase in allowable stress for wind combined loading shall be waived. Strength of the steel at yield shall be 55,000 PSI and taper of pole shaft shall be 0.14 inches per linear foot. Counterweight pole shaft shall be of constant diameter.

4. Pole Deflection: The lateral deflection of the pole shall be tested by applying the maximum working bending moment, as shown on the contract plans, to the pole. The horizontal load shall be applied at a point 18” from the top of the pole.

   a) Lateral deflections of tapered tubular poles shall not exceed 2 percent of the pole height when measured at the top of the pole.

   b) Lateral deflection of tubular counterweight poles shall not exceed 1 percent of the pole height when measured at the top of the pole.

2.02 MATERIALS

A. Poles: Pole shafts, handhole reinforcements, covers and base covers shall be fabricated from one structural steel material type conforming to the following specifications:

1. ASTM A283, Grade D, modified, with a guaranteed minimum yield strength of 42,000 PSI.

2. ASTM A572/A572M, Grades 345, 380, 415, or 450.

3. ASTM A595, Grades A or B, with a guaranteed minimum yield strength of 55,000 PSI for pole shafts.

B. Vandal/Tamper Resistant Hardware: Hardware and fastening devices shall be vandal/tamper resistant to prevent unauthorized tampering and/or disassembly of completed pole installations. Unless otherwise noted, fasteners, including bolts, screws, nuts, and washers, shall conform to the following standards:

1. ASTM A307: Carbon steel bolts and studs.

2. ASTM A563, Grade A: Carbon and alloy steel nuts, heavy hex.

3. ASTM F436: Hardened steel washers, Type 1.

4. ASTM F93: Stainless steel bolts, hex cap screws and nuts.

C. Base Plate: Base plates shall be fabricated from structural steel conforming to ASTM A572/A572M Grades 290 or 345, or ASTM A36/A36M. The minimum yield stress capacity of the base plate steel shall be not less than 75 percent of the yield stress capacity of the pole shaft steel.

D. Pole Caps: Pole caps shall be galvanized pressed steel, fitted with 3 tamper resistant stainless steel set screws.

E. Handhole Cover Screws: Handhole cover screws shall be tamper resistant stainless steel Allen-type set screws. Tapped holes in the handhole frames may be furnished instead of nuts welded to the handhole frames.

F. Feeder Spouts: Feeder spouts shall be standard steel pipe conforming to ASTM A53/A53M, Type S, Grades A or B.

G. Sheave Hole Cover: The cover material for the sheave hole in the counterweight pole shall be a 2-piece bent plate of stainless steel as indicated in the Contract Plans.

H. Miscellaneous Structural Steel: Structural steel shall conform to the following specifications, unless otherwise specified:

1. Round Tubular Sections: ASTM A36/A36M

2. Other Sections: ASTM A36/A36M

I. Weld Filler: Weld filler metal shall be selected in compliance with Article 1.03.B.1, and shall conform to AWS D1.1.

J. Zinc: Zinc used for hot-galvanized coating shall be Prime Western Grade, or VTA-approved equal, conforming to ASTM B6.

K. Series 90-93 as manufactured by Tnemec Co., Inc.; Carbo-zinc SP81 as manufactured Caboline; or VTA-approved equal.

L. Galvanizing repair compound shall conform to Federal Specification DOD-P-20135, Glavaloy Metalloy Products Co., Hardhat 2185 by Rust-Oleum, ZRC by ZRC Chemical Products, or VTA-approved equal.

M. Powder coating of OCS poles and base covers shall be in accordance with Section 05 05 13 “Shop Applied Coatings for Metals”, Article 2.02.D of these Technical Specifications.

1. Color: White (WH)

2. Gloss: Medium gloss.

2.03 FABRICATION

A. General: Poles, base covers, fittings, and accessories shall be fabricated to the dimensions shown on VTA LRT Standard Detail Manual and the Plans.

B. Methods and Tolerances: Poles, mast arm supports, fittings, and accessories shall be fabricated by methods and within tolerances conforming to the AISC S302 and AISC S335, except as specified herein.

C. Tolerances:

1. Diameter: The outside diameter shall conform to the specified dimensions with a tolerance of + 1/16 inch as measured by girthing.

2. Wall Thickness: Wall thickness shall be within + 10 percent or - 5 percent of the design thickness.

3. Taper: Taper shall be constant for the length of the pole as indicated on VTA LRT Standard Detail Manual and the Plans.

4. Straightness: Straightness shall be with 1:500 of pole length.

5. Tolerances for base plate shall be as follows:

a. Bolt Circle: + 1/16”.

b. Hole Diameter: +1/16”, - 0”.

c. Location of Holes: + 1/16” in each direction.

D. Welding Procedures: Welding procedures, welders, welding operations and tackers shall conform to the provisions of AWS D1.1, Section 2, "Design of Welded Connections," Section 3, "Workmanship," Section 4, "Technique;" and Sections 8, 9, and 10.

E. Weld Repair: Welds found to be unacceptable shall be repaired in conformance with the provisions of AWS D1.1, Section 3, "Workmanship."

F. Surface Grinding: Before galvanizing, all penetration welds shall be ground flush with base metal to eliminate surface cracks. All other welds and cut edges shall be ground to eliminate sharp edges and burrs. Feeder spouts shall be ground smooth around the edges and cleared of all burrs to protect feeder cables against abrasion.

G. Embrittlement: Fabrication shall conform to ASTM A143 to prevent embrittlement of the steel.

H. Galvanizing: After fabrication, the poles, fittings and accessories shall be hot-dip galvanized inside and out, in conformance with ASTM A123/A123M or ASTM A153/A153M, as appropriate. All fabrications shall be galvanized for their entire length, at one time, in a single hot-dip galvanizing bath. Galvanizing by successive dippings of partial pole lengths will not be permitted.

I. Straightening: After galvanizing, and cooling to ambient temperature, the poles shall be straightened as necessary to conform to the specified requirements. Straightening methods shall not require heating of the poles and shall not damage the zinc coating.

J. Pole Identification Plate: A stainless steel pole identification plate shall be attached to each pole immediately above the handhole, or 24 inches above the base plate. The plate shall show the pole type, structure number, and the manufacturer's name and date of manufacture. The plate design, style of lettering and method of attachment shall be reviewed by VTA. Additional requirements for structure numbering are specified in Section 34 23 53, "Overhead Contact System Installation," Article 3.24.

K. Feeder Spout: The area of the feeder spout that is in contact with the cables shall be free of rough edges and shall be ground smooth to prevent damaging the cable insulation.

L. Powder coating of OCS Poles and Accessories: Powder coating shall be performed in the factory or in the field following recommendations of supplier.

PART 3 – EXECUTION

3.01 CONSTRUCTION – POLE SETTING

A. General:

1. Metal Poles shall be installed where shown on the Plans. Contractor shall install 1 nut and washer against the bottom of pole base plate at each anchor bolt and install 2 nuts and 1 washer against the top of the base plate at each anchor bolt. Contractor shall also furnish and install all fittings required for the specific installation including but not limited to the following items:

    a) Handholes.

    b) Feeder spouts.

    c) Counterweight holes for sheaves, and sheave covers.

    d) Brackets for down guy anchors.

    e) Bar signal supports.

2. Metal Pole Extensions shall be installed where shown on the Plans. Contractor shall place the extension onto the existing pole to be extended after all attachments have been temporarily removed and/or relocated. Once all attachments have been cleared, the extension piece shall be placed on and pressed onto the existing pole with a force recommended by the pole manufacturer. The contractor shall finalize the installation by installing a boxbolt (blind bolt) as shown on the Plans. After installation of the pole

extensions, the Contractor shall re-attach any and all assemblies temporarily removed and/or relocated. Such attachments include but not limited to:

a) Surge Arrester: Contractor shall temporarily remove/relocate existing surge arresters prior to pole extension installation. Surge arrester shall be re-installed at the top of the pole extension above the proposed parallel aerial feeder cables. Splicing of the surge arrester ground cable may be recurred. Re-installation of the surge arrester will require new poles bands and filled drilled 1 1/2" diameter hole with rubber gromet for the surge arrester ground wire. The hole shall be galvanized as specified in Article 3.02.

b) Midpoint Anchor Assembly: Contractor shall temporarily remove/relocate existing Midpoint Anchor Assemblies prior to pole extension installation. Reinstallation of the Midpoint Anchor Assembly will require new pole connection with the pole band steel guy wire dimensioned based on the proposed diameter of the pole extension. The Midpoint Anchor Assembly shall have a nominal tension of 1550 lbs at 60°F.

c) Phillystran Kevlar Rope: Contractor shall temporarily remove/relocate existing Phillystran Kevlar Rope attachment prior to pole extension installation. Reinstallation of the Phillystran Kevlar Rope will require a new pole band.

B. Check and verify that the TES pole foundations have been installed at the location as shown on the OCS layout schedule. This includes checking each foundation with base template (supplied by VTA) to ensure that the anchor bolt spacing and size is correct for the TES pole to be placed on that foundation. Also verify that the correct conduits, if required, are in place. This must be done 15 working days before the planned setting of the poles, and any deviations shall be brought to the attention of VTA.

C. Preparation of Pole Foundation: Steel poles are of the anchor base type, for installation on concrete piers or structures with projecting anchor bolts left in place for setting and bolting of poles.

D. Following removal of debris and cleaning of surfaces, pole foundations shall be inspected for structural soundness and correct anchor bolt settings and tolerances, and any damage corrected, before steel poles are set in place.

E. Perform any corrective work to the TES pole foundations, such as chipping of concrete, cleaning of bolt threads, straightening bolts, welding of broken bolts and procuring nut and washers for the anchor bolts. After the TES pole has been set, a minimum of 2 threads must protrude above the top nut.

F. The following procedure is to be used for straightening TES anchor bolts and down-guy anchor bolts when authorized by VTA:

1. Inspect the bolt or down guy anchor for cracks; remove galvanizing from area of concern and apply liquid penetrant.

2. Use mechanical means to straighten anchor bolts.

3. Repair galvanizing.

G. When a pole, transported to the site, requires temporary storage before setting onto the foundation, it shall be stored above ground and in such a manner that it does not interfere with other contractors' work or create a hazardous condition.

H. The type, location, setting height, and initial rake of each pole shall be as indicated on the OCS layout schedule. The pole rake value is applicable to the pole in the unloaded condition. Poles installed under this Contract should be plumb after the OCS has been installed and the pole is fully loaded. It may be necessary to re-rake certain poles should these be out of alignment after loading. Upon approval by VTA, re-raking will be paid by VTA.

I. Poles with hand-holes shall be installed such that the hand hole is located on the opposite side of the poles from vehicle travel on side poles. On center poles, the hand hole shall be located so that access faces parallel to the track.

J. Poles shall be handled and erected using nylon or similar non-marking slings and chokers. Minor damage to galvanized or painted surfaces may be field repaired by approved touch-up paint or VTA-approved cold galvanize, applied in accordance with the manufacturer's instructions. Major damage to the poles may require that the pole involved be replaced. VTA shall be the sole judge of acceptable repairs.

K. After acceptance of a completed line section, and on the order of VTA, grout all pole bases with a VTA-approved non-shrink grout. Finished grout shall be neatly, chamfered and free of cracks and other defects. At all poles, a 1" diameter weep hole shall be provided through the grout to allow water to drain from the inside of the pole.

L. Poles shall be covered by a suitable pole cap which shall be installed on the pole before setting of the poles.

M. Pole base cover, where required, shall be installed after the complete installation of the poles.

N. Cutting of Steel Poles: Cutting of poles shall be done only where approved by VTA for the individual case. Where poles are cut, the cutting shall be done neatly, galvanized surfaces repaired, and caps fitted so that cut poles are installed to the standards specified herein for all other steel poles. Poles shall be cut in accordance with manufacturer's recommendations to not invalidate the warranty.

O. After the grouting is completed and accepted by VTA, install pole base covers at stations, paved areas, pedestals and sidewalks. Where necessary, the base cover does not sit on a concrete surface, additional grouting (filling) of the base is required. Base covers shall be aligned with either the curb or the track, whichever applies.

P. Pole hand holes are to be covered by appropriate handhole covers. They shall be properly mounted, secured to the pole with the number of screws as recommended by the manufacturer.

Q. Contractor shall obtain actual "as-built" information of each installed pole, by field measurement if necessary, and use that information to update the various dimensions shown on the OCS layout schedule.

R. Feeder Poles:

1. Cable supports shall be wire basket type and shall be capable of supporting the vertical weight of the cable. Grip shall be suspended from the "J" hook inside the top of the pole. Cable exits from the feeder spouts shall be sealed with terminating bushings.

2. Feeder poles shall be installed with the spout facing the track where the feeder cables will be connected to facilitate cable connections to contact wires.

S. Counterweight Poles: Sheave hole covers shall be installed on the counterweight poles as indicated on the Plans after the OCS wiring installation is complete.

T. Grounding: All steel poles installed by Contractor shall be grounded as shown on the Plans.

U. Additional Requirements:

1. If original foundations are replaced before poles are set, the poles shall be set not less than 7 days after foundations are installed, and loaded to design requirements not less than 30 days after foundations are installed.

2. Contractor shall exercise care during erection of poles to prevent abuse and disfigurement of poles. All imperfections on the steel poles shall be repaired as necessary to restore poles to a condition acceptable to VTA. Damage to galvanized coatings shall be touched up as specified in Article 3.02.

3. Caution is advised during steel pole erection to prevent contact with other overhead, and possibly energized, utilities.

3.02 TOUCH-UP

A. Immediately after erection, any shop coatings shall be removed from field welds and bolted connections.

B. Areas of damaged galvanizing shall be coated with a galvanizing repair compound.

C. Areas of damaged paint shall be repaired in accordance with the manufacturer’s recommendations.

3.03 FIELD QUALITY CONTROL

A. Delivered poles, fittings and accessories will be inspected for conformance with requirements of this Section. The poles, fittings and accessories that are not acceptable shall either be repaired or removed at no additional expense to VTA.

END OF SECTION 34 23 13

SECTION 34 23 15

OVERHEAD CONTACT SYSTEM POLE AND GUY ANCHOR FOUNDATIONS

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for furnishing and installing Overhead Contact System (OCS) pole(s) cast-in-drilled hole (CIDH) pile foundations and guy anchor CIDH pile foundations.

B. Reference is made to the OCS pole foundation in the civil works section of this contract, aerial guideway structure, for work items that must be closely coordinated with installation of the overhead contact system.

C. Related Sections: The work of the following Sections is related to the work of the Section. Other Sections, not referenced below may be related to the proper performance of this work.

1. Section 03 05 15 – Portland Cement Concrete
2. Section 03 20 00 – Concrete Reinforcing
3. Section 03 30 00 – Cast-In-Place Concrete
4. Section 03 62 00 – Non-Shrink Grouting
5. Section 26 05 26 – Grounding and Bonding for Electrical Systems
6. Section 26 05 33 – Conduits and Boxes for Electrical Systems
7. Section 31 00 00 – Earthwork
8. Section 31 63 29 – Drilled Concrete Piers and Shafts

1.02 REFERENCED STANDARDS

A. American Concrete Institute (ACI):

1. ACI 301 Specifications for Structural Concrete
2. ACI 305R Guide to Hot Weather Concreting
3. ACI 306.1 Standard Specification for Cold Weather Concreting
4. ACI 318 Building Code Requirements for Structural Concrete and Commentary
5. ACI 336.1 Specification for the Construction of Drilled Piers

B. American Society for Testing and Materials (ASTM):

1.	ASTM A36	Standard Specification for Carbon Structural Steel
2.	ASTM A153	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
3.	ASTM A252	Standard Specification for Welded and Seamless Steel Pipe Piles
4.	ASTM A354	Standard Specification for Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners
5.	ASTM A563	Standard Specification for Carbon and Alloy Steel Nuts
6.	ASTM A668	Standard Specification for Steel Forging, Carbon and Alloy, for General Industrial Use
7.	ASTM C31	Standard Practice for Making and Curing Concrete Test Specimens in the Field
8.	ASTM C39	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
9.	ASTM C42	Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
10.	ASTM C143	Standard Test Method for Slump of Hydraulic-Cement Concrete
11.	ASTM C150	Standard Specification for Portland Cement
12.	ASTM C172	Standard Practice for Sampling Freshly Mixed Concrete
13.	ASTM C827	Standard Test Method for Change in Height at Early Ages of Cylindrical Specimens from Cementitious Mixtures
14.	ASTM C881	Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
15.	ASTM C882	Standard Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete by Slant Sheer
16.	ASTM F1554	Anchor Bolts, Steel, 36, 55, 105, KSI Yield Strength

1.03 SUBMITTALS

A. Test Reports: Submit testing laboratory reports for tests.

1. Compressive strength tests shall contain the following:

a. Project identification name and number.

b. Data of concrete placement.

c. Name of Contractor.

d. Name of concrete testing service.

e. Concrete type and class.

f. Structure numbers and stationing of foundations poured with each batch.

g. Design compressive strength at 28 days.

h. Concrete mix proportions and materials.

i. Compressive breaking strength and type of break for both 7-day test and 28-day test.

B. Excavation Plan:

1. Provide detailed workplan listing equipment and procedures used in excavation for OCS pole foundations.

2. Provide procedures for dewatering and copy of valid permit for disposal of contaminated water.

3. Provide procedure for removal of soil from site, final location of disposal, and method of testing.

C. Anchor Bolts:

1. Provide certificates from the mill for manufacture and strength tests for delivered lot.

2. Provide shop drawings of guy anchor rods, anchor bolts, washers, and nuts.

D. Epoxy Resin Grout.

E. Record of stations and offset of installed foundations (tolerance ± ½ inch) and field notes (changes to depth, etc.)

1.04 QUALITY ASSURANCE

A. Codes and Standards: Perform work in compliance with the applicable requirements of governing authorities having jurisdiction, including provisions for adequate protection to persons and property and ACI 336.1.

B. The Geotechnical Engineer will be VTA's representative to observe the installation of all CIDH piles. The Geotechnical Engineer must approve the method of installation, substantiate the adequacy of the soil materials encountered in the excavations, and submit a written report regarding the ability of the CIDH piles to support the design loads.

C. Prior to placing concrete, all CIDH pile excavations must be evaluated by the Geotechnical Engineer. Sufficient time must be provided to allow the Geotechnical Engineer to evaluate the adequacy of the foundation material, measure CIDH pile dimensions, plumbness, and amount of water, if any, at the bottom of the shaft. No concrete shall be placed without the approval of the Geotechnical Engineer. During concrete placement, the Geotechnical Engineer shall observe the method and record any deviations from the requirements set for in these specifications. CIDH piles completed without approval may be rejected and must, in the event of such rejection, be replaced at the Contractor's expense.

D. Design Mix:

1. Once a design for any class of concrete is established it shall not be varied as to source, quantity, quality, grading of materials, or proportioning, or in any other way.

2. Proposed changes shall be accomplished by preparing a new design mix as specified.

3. Provide mix designs specifically suited for various methods of CIDH pile foundation construction.

E. Sampling and Testing: Sample concrete ingredients prior to use and have them tested by an approved laboratory in accordance with the methods specified. Subsequently test materials as often as necessary to verify that the materials conform to the specifications and that quality of product is maintained.

F. Electrical conduits to be installed by licensed electricians.

1.05 MEASUREMENT AND PAYMENT

A. Measurement: Pole and Guy Anchor Foundations (CIDH) shall be measured by the unit price (LF).

B. Payment:

1. Pole Foundations: The contract price paid per unit price (LF) for Pole Foundations (CIDH) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Pole Foundations (CIDH) complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by VTA.

2. Down Guy Foundations: The contract price paid per unit price (LF) for Guy Anchor Foundations (CIDH) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Guy Anchor Foundations (CIDH) complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by VTA

PART 2 – PRODUCTS

2.01 EQUIPMENT

A. Provide drilling rig equipped with two-way leveling and two-way horizontal positioning. Rig to be of sufficient power, weight and shaft length to drill to indicated depth through soils conforming generally to those indicated as existing on site by the Geotechnical report.

2.02 REINFORCING CAGE CENTRALIZER

A. Device that centers reinforcing cage in the opening and ensures specified concrete cover.

2.03 CONCRETE

A. Cement: ASTM C150, normal - Type II, Portland cement, gray color. Use only one brand of Portland cement throughout the Contract unless otherwise approved.

B. Compressive Strength (28 days): 4000 psi.

C. Slump: 2 - 4 inches.

D. Maximum aggregate size: 3/4 inch.

2.04 FORM MATERIALS

A. Steel Casing: Welded, ASTM A 36/A 36M or A 252; thickness as required but not less than 1/4 inch.

B. Treated Paper (cardboard): For circular formed shapes only, shall be designed specifically for use as a concrete form above ground, with waterproof surface treatment, diameter as required, removable, one use only.

2.05 REINFORCEMENT

A. Reinforcing bars for OCS pole and Guy Anchor CIDH foundations shall be deformed bars complying with ASTM A 615, Grade 60, Class 2A.

2.06 ANCHOR BOLTS

A. Anchor bolts and nuts shall be dimensioned and manufactured to specifically work together. Extra washers and nuts left over at the completion of pole installation shall be delivered to VTA and will become the property of VTA. Contractor shall obtain a receipt from VTA documenting delivery and quantity of left-over washers and nuts.

B. High-strength carbon steel bolts; F1554 Grade 55, overtapped threads in accordance with AISC requirements for UNC Series.

C. Galvanizing complying with ASTM A 153/A 153M.

D. Nuts shall comply with ASTM A 563 Grade DH, hot-dip galvanized, overtapped threads.

E. Anchor bolt assembly will be embedded in the pole or down guy foundation, ready for pole or down guy installation.

2.07 CLEVIS CONNECTOR AND COUPLER SLEEVE

A. Forged steel: ASTM A 668.

B. Galvanizing complying with ASTM A 153/A 153M.

2.08 CONDUITS AND PILE SLEEVES

A. Comply with the requirements of Section 26 05 29 “Supports for Electrical Systems,” for conduit and pipe sleeves. The size shall be as shown on the Contract Drawings.

2.09 NON-SHRINK GROUT

A. Non-Shrink Grout shall confirm to the requirements in Section 03 62 00, “Non-Shrink Grouting” of these Technical Specifications.

2.10 EPOXY-RESIN GROUT

A. Epoxy-Resin Grout shall confirm to the requirements in Section 03 62 00, “Non-Shrink Grouting, of these Technical Specifications.

B. Pre-packaged option:

1. Resin cartridges with casing constructed of a saturated polyester providing optimum resistance to moisture but easily ruptured to enable complete mixing and integration with hole side walls during installation.

2. Cartridge shall contain two distinct fractions of unsaturated polyester resin and catalyst without an intervening mechanical membrane.

3. Resin shall be high strength polyester with non-reactive inorganic filler.

4. Catalyst shall contain peroxide with non-reactive inorganic filler.

5. Materials shall have thixotropic and viscous properties to permit adequate mixing of the materials by manipulating the embedded anchor or bar.

6. Shelf life of the epoxy-resin shall be not less than six months.

7. Gel and cure time shall be within 10 minutes after completion of installation.

PART 3 – EXECUTION

3.01 SITE TOLERANCES

A. OCS pole foundation horizontal tolerances.

1. Along track:

a) Foundation in ballast: ± 2 feet.

b) Foundation at station platforms: ± 1 inch

2. Across track: ± 1 inch.

B. Down guy anchor foundation horizontal tolerances.

1. Along track: ± 12 inches relative to the center of OCS pole foundation being anchored.

2. Across track: ± 3 inches.

3.02 CONSTRUCTION TOLERANCES

A. Pole and Guy Anchor Foundations:

1. Plumb: Drilled CIDH pile out-of-plumb dimensions shall be checked after excavation and before concreting. The maximum tolerance shall be 1.5 percent of length or 12.5 percent of shaft diameter, whichever is less. This tolerance applies to the diameter dimension as shown on the Contract Drawings, and it does not include excavation over-cutting when it occurs. Excavations which exceed this tolerance shall be reviewed in consultation with the Engineer and if an optional location is available that will not seriously impact the OCS wiring, the excavation shall be rejected, backfilled, and the CIDH pile relocated, with all related costs for the work including the original drilling to be the Contractor's responsibility. Should relocation of the foundation not be an option an alternative design shall be considered, such as oversizing the foundation diameter with all related costs for the work to be the Contractor's responsibility.

2. Tops of foundations and anchors: Within 1 inch above or below the required levels shown on the Contract Drawings.

3. Cut and bend reinforcing steel to conform to dimensions as shown on the Contract Drawings within the following tolerances:

    a. Shear length: ± 1 inch.

    b. Stirrups, ties and spirals: ± 1/2 inch.

    c. All other bends: ± 1 inch.

B. Anchor bolts: Locate as shown on the Contract Drawings installed plumb and within the following tolerances relative to the top of the foundation:

1. Horizontal: ± 1/8 inch of true square, the center of which shall meet the tolerance requirements for the foundation.

2. Vertical: ± 1/4 inch. Provide templates for anchor bolts to ensure correct alignment.

C. Foundation: Size shall conform to the dimensions shown on the Contract Drawings within the following tolerances:

1. Diameter: ± 1 inch.

2. Depth: + 2 feet - 0 feet.

3. Foundation size tolerances shall not decrease the required minimum concrete cover.

3.03 PREPARATION

A. Schedule excavation, boring, installation of reinforcing steel, installation of conduits, and concrete pouring so that each excavated area is poured immediately after excavation is complete and reinforcing steel and conduits are placed and approved.

B. Prior to performing excavation or other work, locate underground utilities. If there are no apparent conflicts, hand excavate each individual location to a depth of 4 feet and to the dimensions indicated on the Contract Drawings. Additional excavation may be performed by other methods.

C. Should uncharted or incorrectly charted piping or other utilities be encountered, consult the Engineer immediately for direction as to procedure. Cooperate with the Owner, and public or private utility companies in keeping their respective services and facilities in operation. Repair damaged utilities to the satisfaction of the utility owner.

D. Locate and stake out foundation locations and determine foundation elevations utilizing the working line (alignment) and project datum established as shown on the Contract Drawings.

E. Protect excavations by shoring, bracing, temporary casing or other methods required to prevent cave-in or loose soil from falling into excavation.

F. Safeguard open foundations left unattended.

3.04 DRILLING

A. Excavation cannot begin until Contractor's Excavation Plan is approved by Geotechnial Engineer.

B. Notify the Owner's Geotechnical Engineer at least four working days in advance of the beginning of drilling operations or on resumption of drilling after stoppage. Any hole drilled or cast without continuous observation by the Owner's Geotechnical Engineer will be rejected.

C. Drill holes for CIDH piles to the required elevation/depth, as shown on the drawings.

D. Take necessary measures to prevent hole caving or sloughing.

E. Drilling slurry shall not be used, except with the written approval of the Geotechnical Engineer and submittal of a comprehensive slurry displacement plan.

F. Keep holes free from water to the extent possible. Water may be introduced only in small amounts as required to raise cuttings; amount and procedure subject to approval by the Geotechnical Engineer.

G. Clean CIDH pile bottoms to remove soils loosened by drilling action.

H. Do not drill holes that cannot be concreted the same day.

I. Make use of all existing subsurface information to determine the nature of subsurface soils and presence of ground water. Select a method of excavation at each foundation site that meets all Contract requirements.

J. Locate the centerline of the CIDH piles on the centerline of bearing construction, unless otherwise shown on the drawings. Cross stake each CIDH pile centerline to preserve locations for installing dowels, anchors, reinforcing.

K. Maintain the excavation in a manner suitable to install reinforcement, down guy anchor rods, anchor bolts and concrete.

L. Water control: Prevent surface and/or subsurface water from flowing into excavations and from flooding project site and surrounding areas.

1. Do not allow water to accumulate in excavations. Continually remove water to prevent softening of foundation bottoms, undercutting footings or slabs, and soil changes detrimental to stability of subgrades and foundations.

2. Provide and maintain dewatering system components necessary to convey water away from excavations in a procedure approved by the Engineer.

M. Remove excavated material and legally dispose of it off the site, unless otherwise approved by the Owner. In excavating (by mechanical or hand methods) do not disturb the bottom of the excavation. Trim bottoms to required lines and grades leaving a solid base to receive concrete. Loose soil at the bottom of the foundation excavation shall not exceed 3 inches depth.

N. Excavations shall be stable and shall not affect the integrity of adjacent structures.

O. When drilling excavation methods are unsuccessful due to soil cave-ins or presence of ground water, use a different method that will meet requirements of these Specifications.

P. If unsuitable bearing materials are encountered at the required subgrade elevations, revise the foundation excavation as required by the Engineer.

Q. Excavations, which do not meet Contract requirements, shall be backfilled with concrete and new excavations made at the Contractor's expense.

3.05 TEMPORARY STEEL CASING

A. Holes need not be cased unless hole sloughs or is otherwise unstable as determined by the Geotechnical Engineer. If hole is unstable, provide steel casing for shaft excavation where required.

B. Provide casing of sufficient strength to withstand handling stresses, concrete pressure, and surrounding earth and/or fluid pressures.

C. Select diameter of casing in relation to diameter of CIDH pile excavation, such as to create a minimum of void space outside of the casing.

D. Hole may be drilled as deep as it will stand prior to setting casing, but do not drill hole ahead of casing any further than hole will stand without sloughing. Where sloughing occurs, case hole to bottom of sloughing area immediately prior to drilling deeper in hole.

E. If hole is dewatered and the base is in the dry, hold casing clear of bottom of hole, such that any seepage around the casing drains into bottom of hole and water does not accumulate between casing and hole sidewall.

F. When removing the casing, ensure that the level of the concrete being poured is 5 feet higher than the bottom of the casing. Failure to remove temporary casing will result in CIDH pile being deemed unsuitable.

3.06 DEWATERING AND CLEANING

A. If depth of water in hole exceeds three inches, hole must be dewatered to within the specified limit immediately prior to casting.

B. Seepage water entering hole during casting must not exceed ACI guidelines.

C. All CIDH pile bottoms must be cleaned of loosened material to the satisfaction of the Geotechnical Engineer. Straight sided CIDH piles can conceivably be cleaned with proper drilling equipment.

3.07 REINFORCEMENT, DOWN GUY ANCHOR RODS, AND ANCHOR BOLTS

A. All materials shall be delivered in solid, sturdy containers and delivery shall be accompanied by packing slips.

B. Fabricate and erect reinforcing cages as one continuous unit. Place reinforcement accurately and symmetrically about axis of hole and hold securely in position during concrete placement.

C. In no case shall bars, prefabricated bar cages, or down guy anchor rods, anchor bolts be pushed or lowered into concrete which have been placed in an excavated hole prior to reinforcement placement.

D. Minimum clear concrete cover shall be 3 inches. Fit reinforcement assembly with approved devices to ensure that required minimum concrete cover is obtained.

E. Arrange and place anchor bolts and down guy anchor rods as shown on the Contract Drawings. Provide template to ensure correct alignment.

F. Anchor bolts shall not physically contact reinforcing steel or other embedded metallic items. Protect exposed ends of anchor bolts from mechanical damage and exposure to the weather.

G. Secure anchor bolts and down guy anchor rods positively against displacement during placing of concrete.

H. Depending upon the security of the installation from theft, anchor nuts shall at the Contractor’s risk be removed or cinched on the bolts.

3.08 INSTALLING CONDUITS

A. Install conduits in OCS foundation for feeding structures as shown on the Contract Drawings.

B. Use the size and general routing as shown on the Contract Drawings.

C. Use the type of conduit specified in Section 26 05 29, “Support for Electrical Systems.”

D. Install conduit and conduit bends in accordance with Section 26 05 33, Raceway and Boxes for Electrical Systems.

E. Support conduits to prevent movement, distortion and damage during placement of concrete.

F. Cap ends of conduits and install pull cords prior to placement of concrete. At all stages of the work, exercise care to prevent foreign materials from entering the conduits.

G. In the event there is no room to stub up the second feeder conduit in the foundation, Contractor shall obtain Resident Engineer’s approval to stub it up adjacent to foundation and cap.

3.09 PLACING CONCRETE

A. See Section 03 30 00, Cast-In-Place Concrete, for placement of concrete for footings, pile caps, pilasters and CIDH piles.

B. After approval has been obtained of the excavation, reinforcement and embedded items, immediately fill CIDH pile excavations with concrete. Provide edge protection as required to prevent edge spalling and dirt contaminating concrete.

C. Place concrete continuously without interruption and in a smooth flow without segregating the mixed materials. Provide mechanical vibration for consolidation of at least the top 10 feet of each CIDH pile, but only after the casing has been pulled.

D. Place concrete in-the-dry or where not more than 3 inches of water is in the hole. In the event that water occurs, place concrete by the tremie method. Set tremie pipe in center of reinforcing cage and 6 inches off bottom of hole, when reinforcing cage is properly set. Tremie pipe shall not be raised until the concrete surface in hole is at least 5 feet above the bottom of tremie pipe or until pour is completed, including removal of muck and unsuitable concrete. Pumping of concrete shall be continued until all muck and unsuitable concrete have been lifted to top of shaft elevation and removed, and entire pour consists of suitable concrete.

E. After completion, vibrate concrete to a depth of at least 10 feet below top of shaft. Remove standing water and any unsuitable concrete raised by consolidation.

F. Prevent extraneous material from mixing with the fresh concrete.

G. If temporary steel casing is required to prevent cave-in, casing shall be withdrawn as concrete is placed. A minimum head of 5 feet of concrete shall be maintained within the casing at all times to prevent reduction of the diameter of the drilled shaft due to earth or hydrostatic pressure on the fresh concrete.

H. Stop the concrete placement at the cut-off elevation shown, screed off with slight slope to exterior for water drainage. Form the top section above grade to the required elevation.

I. Interrupted placing operations of over one hour duration will require a cold joint installation. Leave the resulting shaft surface approximately level. If shaft is not reinforced, insert steel dowels as required.

J. At resumption of concrete placing, clean off surface laitance, roughen as required treating existence surface as a construction joint.

3.10 DEFECTIVE WORK

A. The Contractor's proposed procedure for backfilling any excavation shall be approved by the Engineer on a site-specific basis before the backfilling proceeds.

B. In the event the Geotechnical Engineer deems a CIDH pile unsuitable, based on the observations of the Geotechnical Engineer, the Owner will establish remedial work, and the Contractor shall bear cost of remedy.

C. Any CIDH pile drilled or placed without continuous observation by the Geotechnical Engineer will be deemed unsuitable.

3.11 FIELD QUALITY CONTROL

A. Sampling Fresh Concrete: ASTM C 172, except as modified for slump to comply with these Specifications.

B. Slump: ASTM C 143/C 143M; one test for each concrete load at point of discharge; and one for each set of compressive strength specimens. Do not use concrete that has slump outside the specified values.

C. Concrete Temperature: Test daily when air temperature is 40 degrees F and below, and when 80 degrees F and above; and each time a set of compression test specimens is made.

D. Compression Test Specimens: ASTM C 31/C 31M.

E. Compressive Strength Tests: ASTM C 39.

1. Compressive strength tests for laboratory-cured cylinders will be considered satisfactory if the averages of all sets of three consecutive compressive strength test results equal or exceed the 28-day design compressive strength of the type or class of concrete; and, no individual strength test falls below the required compressive strength by more than 500 PSI.

2. If the compressive strength tests fail to meet the minimum requirements specified, the concrete represented by such tests will be considered deficient in strength and rejected for inclusion in the work.

F. Testing of in-place concrete.

1. The Contractor shall perform tests on in-place concrete when test results from samples indicate the specified concrete strengths and other characteristics have not been attained in the structure.

2. Tests shall determine the strength and other characteristics of in-place concrete by compression tests on cored cylinders complying with ASTM C 42/C 42M, or by load testing specified in ACI 318, or other acceptable non-destructive testing methods, as directed.

3. The Contractor shall pay for such tests conducted, and all other additional testing as may be required, when unacceptable concrete is verified.

G. When directed, replace concrete not conforming to required levels and lines, details, and elevations at the Contractor's expense.

H. Grounding: Test ground resistance of installed ground rods after concrete has cured in accordance with Section 26 05 26, Grounding and Bonding for Electrical Systems, for acceptance criteria.

3.12 CLEANING

A. Clean forms to remove foreign matter as installation proceeds.

B. Use compressed air or other approved methods to remove foreign matter.

3.13 PROTECTION

A. Immediately after placement, protect concrete from mechanical injury.

B. During the curing period, protect concrete from damaging mechanical disturbances, including load stresses, heavy shock, excessive vibration, and from damage caused by rain or flowing water.

C. Protect all finished concrete surfaces from damage by subsequent construction operations.

D. Provide brightly colored temporary protection arrows around all exposed anchor bolts.

3.14 NON-SHRINK GROUTING

A. Non-shrink grout shall be placed under OCS pole base plates and guy anchor base plates as required in Section 03 62 00, "Non-Shrink Grouting" of these Technical Specifications.

3.15 CURING

A. Immediately after placement, protect freshly placed concrete from premature drying.

B. Maintain concrete without drying at a relatively constant temperature for the period of time necessary for hydration of the cement and proper hardening of the concrete.

C. Begin final curing procedures immediately following hydration of the cement and proper hardening and before the concrete has dried. Continue final curing for at least seven days and in accordance with ACI 301. Avoid rapid drying at the end of the final curing period.

D. For curing, use only water that is free of impurities that could etch or discolor exposed, natural concrete surfaces.

E. Temperature of Concrete During Curing.

1. Maintain concrete temperature as uniformly as possible and protect from rapid atmospheric temperature changes. Avoid temperature changes in concrete that exceed 5 degrees F in one hour and 50 degrees F in a 24-hour period.

2. Atmospheric temperature of 40 degrees F or below: Maintain homogeneous concrete temperature between 50 and 70 degrees F continuously throughout final curing period. Make arrangements before concrete placing for heating, covering, insulation, or housing as required to maintain the specified temperature and moisture conditions continuously for the concrete curing period. Provide cold weather protection complying with the requirements of ACI 306.1.

3. Atmospheric temperature of 80 degrees F or above: Make arrangements before the start of concrete placing for the installation of wind breaks or shading, and for one of the curing methods described below. Provide hot weather protection complying with the requirements of ACI 305R.

F. Curing Methods: Perform curing of concrete by moisture curing, moisture-retaining cover curing, or membrane curing, or by combinations thereof, as approved.

1. Provide moisture curing by any of the following methods:

a. Keep the surface of the concrete continuously wet by covering with water.

b. Water-fog spray continuously.

c. Cover the concrete surface with the specified absorptive cover, thoroughly saturate the cover with water, and keep the absorptive cover continuously wet. Place absorptive cover so as to provide coverage of the concrete surfaces and edges, with a 4-inch lap over adjacent absorptive covers.

2. Provide moisture-retaining cover curing as follows:

a. Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in the widest practicable width with sides and ends lapped at least 3 inches and sealed by waterproof tape or adhesive.

b. Immediately repair all holes or tears during the curing period using cover material and waterproof tape.

END OF SECTION 34 23 15

SECTION 34 23 16

OVERHEAD CONTACT SYSTEM DC INSULATED POWER CABLES

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for furnishing and installing insulated power cables for the DC positive feeders from DC feeder breakers to the catenary, from the parallel feeders to the catenary and other insulated cables as shown on the Plans and specified herein.

B. Related Sections:

1. Section 34 23 00 – General Requirements for Overhead Contact System

2. Section 34 23 39 – Overhead Contact System Assemblies, Components, and Fittings

1.02 REFERENCED STANDARDS

A. American Society for Testing and Materials (ASTM)

1. ASTM B8 Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard or Soft

2. ASTM B33 Standard Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes.

3. ASTM B173 Standard Specification for Rope-Lay-Stranded Copper Conductors Having Concentric-Stranded Members, for Electrical Conductors

4. ASTM B496 Standard Specification for Compact Round Concentric –Lay-Stranded Copper Conductors.

5. ASTM D149 Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.

6. ASTM D543 Standard Practice for Evaluating the Resistance of Plastic to Chemical Resistance.

7. ASTM D570 Standard Test Method for Water Absorption of Plastics.

8. ASTM E84 Standard Test Method for Surface Burning Characteristics of Building Materials.

B. Insulated Cable Engineering Association (ICEA)

1. ICEA S-95-658/NEMA WC 70 Power Cables Rated 2000 Voltas or Less for the Distribution of Electrical Energy.

C. Institute of Electrical and Electronics Engineers (IEEE)

1. IEEE 383 — Class 1E Electrical Cables, Field Splices and Connections for Nuclear Power Generating Stations

D. National Electrical Manufacturers' Association (NEMA)

1. NEMA TC 14 — Standard for Reinforced Thermosetting Resin Conduit (RTRC)
2. NEMA WC 70 — Non-Shielded Power Cable 2000 V or Less

E. National Electrical Testing Association, (NETA)

1. ANSI/NETA A — Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

F. Underwriters Laboratories Inc. (UL)

1. UL 44 — Thermoset-Insulated Wires and Cables
2. UL 94 — Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
3. UL 1581 — Reference Standard for Electrical Wires, Cables and Flexible Cords
4. UL 2515 — Aboveground Reinforced Thermosetting Resin Conduit (RTRC) and fittings

1.03 QUALITY CONTROL

A. Contractor shall perform the following:

1. Material qualification testing and certification for acceptance of materials, components and assemblies.
2. Job control testing of in-progress work being performed in shops, factories, and on-site.
3. On-site inspection of specified work elements.

B. Federal, State, and Local Authorities: Conform to applicable codes and regulations.

C. Materials and components manufactured to applicable foreign standards, including metric standards, are acceptable, provided that Contractor submits written evidence, in the English language, that they are equal or superior to those complying with the standards of this Section listed in Article 1.02, Referenced Standards, and written approval is obtained from VTA.

1.04 SUBMITTALS

A. Manufacturer's data shall be submitted for all items covered under this Section. Shop drawings and/or catalog cuts shall be included. Technical data shall include cable impedance (resistance and inductance) data. Catalog data for proposed tags shall be included.

B. Before installation, the following information for each cable segment shall be provided:

1. Cable pulling data, including distances and tension calculations.

2. Cable pulling equipment and tension monitoring devices.

3. Installation plan, including estimated time for installation of each component and assembly, and plan for protection of cable during installation.

C. "Redline" contract conduit and cable schedule drawings showing final cable numbering, routing, and spare conduits.

1.05 INTERFACES

A. Contractor shall determine interfaces and coordinate both construction work and permanent work with utility companies and VTA.

1.06 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 – PRODUCTS

2.01 GENERAL

A. Cable construction standards, definitions of terms, and conductor installation shall be in strict accordance with applicable publication of ICEA for the cable provided. Insulated cables shall have Class C or G stranding as noted. Conductors for insulated cables shall be made of copper.

2.02 MATERIALS

A. All material shall be of such composition, quality, and purity, that the finished product will have the properties and characteristics described in these technical specifications.

B. DC Power Cable:

1. Description: Insulated power cable shall be copper, with UL rated, 2 kV RHH-2/RHW-2 insulation of high-grade ethylene rubber compound conforming to ICEA S-95-658. The cable shall be of non-shielded construction, with a jacket, and shall be suitable for installation in dry or wet locations.

2. Conductors: Conductors for insulated cable shall be coated, soft drawn copper, complying with ASTM B8 and ASTM B173. Conductor shall be covered with a separator tape when required (for clean stripping for the insulation and/or to avoid the falling off of the insulation between wire strands during the extrusion process).

a) Circuit Breaker Feeder: 500 kcmil soft drawn copper cable, Class C, 61-strands, conforming to ASTM B8, insulated 2 kV rated.

b) Disconnect Switch Feeder and Bypass Disconnect Switch Feeder: 500 kcmil soft drawn copper cable, Class G, 259-strands, conforming to ASTM B8, insulated 2 kV rated.

c) Parallel Feeder Equalizing Tap: 500 kcmil soft drawn copper cable, Class G, 259-

strands, conforming to ASTM B8, insulated 2 kV rated.

d) Surge Arrestor Ground Wire: #4 AWG flex copper cable, insulated, 2 kV rated.

3. Insulation: Ethylene-propylene rubber compound, comply with ICEA S-95-658 and NEMA WC 70. The insulation shall be rated for 194 degrees F operating temperature and 230 degrees F hot spot. The minimum insulation thickness shall be 0.075 inches.

4. Jacket: Low-smoke, flame-retardant, ozone-resistance, UL rated, CT rated, sunlight-resistance, polyolefin thermosetting compound meeting the flame test requirements of UL 1581 and IEEE 383. The minimum jacket thickness shall be 0.065 inches.

5. Shielding: Shielding is not required.

6. Cable Identification: The following information shall be printed on jacket, using contrasting color ink, at not more than two feet intervals.

a) Manufacturer's name.

b) Year of manufacture.

c) Conductor size.

d) Voltage rating.

e) Insulation type and thickness.

f) Jacket type and thickness.

7. Cable Support: Where insulated cables are to be supported from messenger wires, the support shall consist of messenger lashing straps, UV resistant. The lashing strap shall be Thomas & Betts, part number TYM54##XS, or approved equal.

C. Conduits on Aerial Guideway:

1. Conduits shall be epoxy Reinforced Thermosetting Resin Conduit (RTRC), extra heavy wall (XW) of the sizes shown on the contract drawings.

2. Conduits shall be rigid non-metallic zero halogen, fire resistant, and UV stable (Sunlight Resistance).

3. The ends of the conduits entering manholes and/or troughs shall be provided with end bells. End bells shall be of the epoxy reinforced compound manufactured using the same process for manufacturing the conduit. End bells require smooth and round surfaces at the end to prevent injure to the cables.

4. Conduit Marking: All conduits shall be durably and legibly marked in accordance with UL 2515, Section 6. The marking intervals shall not exceed five feet. Elbows shall have at least one of each marking. In addition, the following information shall be printed on the conduit, in lettering not less than 1" high.

a) Conduit size (inches),

b) Wall thickness (inches),

c) UL 2515 listing label,

d) Manufacturer's name,

e) Date of manufacturing,

f) Angle and radius marked on all elbows.

D. Cable Trough:

1. Cable Trough shall be of polymer concrete type, composed of fiberglass reinforced high density polymer concrete material. All raw material used in the production of the cable trough shall be performance certified by the manufacturer of origin.

2. Cable troughs shall be designed to withstand foot traffic on a regular basis without any deformation, deflection or failure as a result of the applied loads.

3. Cable trough shall be designed to accommodate changes in slope on the aerial guideway surface.

4. 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. Each cover shall be provided with appropriate lifting devices for easy removal during cable installation and maintenance. Covers shall be designed to withstand foot traffic on a regular basis without any deformation, deflection or failure as a result of the applied loads.

5. Cable trough shall allow for trouble-free drilling for opening rounded or slotted holes through the sidewall for cable transition to conduits.

6. All mounting and fastening hardware shall be non-magnetic stainless-steel, type 304.

7. Provide one cable trough system for each power section (i.e., Northbound power section, Southbound power section) or one cable trough system that consists of rigid dividers integrated into the body of the trough completely separating the power sections from each other. Each power section compartment shall have their own separate trough cover. The dividers shall be cast from the same polymer concrete material as the trough body and shall be incorporated into the though mold design.

8. Cable trough shall be chemical resistant, fire resistant, and UV radiation resistant.

9. Nameplates: Provide identification nameplates on each cable trough cover identifying each power section. Nameplates shall be metallic sheet with black enamel background and with engraved half inch lettering, and shall be mounted using stainless-steel rivets. Provide nameplates at a minimum of every 100 feet, at all trough ends, and at transitions.

E. Terminations in lugs shall be in accordance with manufacturer's recommendations.

F. Solderless compression terminals shall be high conductivity, corrosion resistant type, as manufactured by Thomas Betts, Burndy, or approved equal. Compression lugs shall be NEMA 2-hole type.

G. All terminals shall use tin or silver-plates copper type connections. All bolts shall be silicon bronze. Aluminum or aluminum alloy terminals shall not be used.

H. Insulated cable splices are not permitted, for Disconnect Switch assemblies and Surge Arrester grounding.

2.03 TESTING

A. The standard dielectric withstand tests shall be performed on each reel of cable before shipment. A certified copy of the test report for each reel of cable shall be furnished to VTA before shipment. A copy of the test report shall also be packed with each reel. The voltage and insulation test requirements shall be in accordance with ICEA S-95-658 and NEMA WC 70.

B. Contractor shall obtain from cable manufacturer the DC testing method and parameters for field testing of the power cables and shall forward them to VTA for review. After the cables have been installed, Contractor shall test them using the aforementioned method and parameters.

2.04 REELS AND PACKAGING

A. The cable shall be furnished on returnable wooden reels. Reels shall be constructed of good materials and shall afford proper protection to the cable during shipment and handling.

B. A watertight seal shall be applied to each end of the cable to prevent the entrance of moisture during transit or out-of-door storage.

C. A durable label shall be securely attached to each flange of each reel. Each label shall indicate the purchase order number, name of manufacturer, reel number, length of cable on reel, description of cable, weight of reel and rolling direction, and source of manufacture.

D. Conduits shall be shipped and stored on self-supporting crates. Crates should not be dropped from the truck trailer flat-beds. The crates shall be stored on a level surface in an environment free from excessive dirt, dust, or other airborne contaminants. The crates shall be designed such that no vertical load is supported by the conduits at any point.

PART 3 – EXECUTION

3.01 GENERAL

A. Contractor shall verify all related cable lengths in the field before placing any order.

3.02 INSTALLATION OF INSULATED CABLES

A. Conductor installation is covered in Section 34 23 53, "Overhead Contact System Installation," of these technical specifications.

B. Inspection and Tests: An insulation test shall be performed by Contractor, and the results recorded and submitted to VTA, as specified in Section 34 23 69, “OCS and TES Interface Testing and Commissioning.”

END OF SECTION 34 23 16

SECTION 34 23 19

OCS POLE MOUNTED DISCONNECT SWITCH

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for OCS pole-mounted, open-style, visible manual DC disconnect switches and all related accessories including mounting hardware.

1. Feeder Disconnect Switch.

2. OCS Sectionalizing (By-Pass) Disconnect Switch

B. Disconnect switches shall be pole-side mounted, complete with manual operating mechanism and vertical connecting rods. Depending on their function in the overall traction electrification system (TES), the switches are classified into 2 groups: feeder disconnect switches and OCS sectionalizing (by-pass) disconnect switches.

C. All the disconnect switches shall be furnished with auxiliary contacts for switch open/closed status indication by remote SCADA interface.

D. Some of the disconnect switches shall be furnished with a dropping resistor and related protective devices and accessories as shown on the plans and specified herein. The switches shall form part of the circuit for the remote monitoring of the OCS voltage status.

E. Contractor shall prepare detailed design for the required switch assembly based on the performance and functional requirements, working loads, and basic dimensions as shown on the Plans. Contractor's switch assembly design and installation details shall be subject to approval and acceptance by VTA.

F. Disconnect switch installation shall be in accordance with Section 34 23 53, "Overhead Contact System Installation," of these technical specifications, and as specified herein.

1.02 REFERENCED STANDARDS

A. American nation Standard Institute (ANSI):

1.	C37.34	Test Code for High-Voltage Air Switches
2.	Z55.1	Gray Finish for Industrial Apparatus and Equipment (Disconnected)

B. American Society for Testing and materials (ASTM):

1.	B187	Standard Specification for Copper bar, Bus Bar, Rod, and Shapes

C. National Electric Manufacturers Association:

1.	250	Enclosures for Electrical Equipment (1000 Volts Maximum)

2. ICS 1 — Industrial Control and System General Requirements

3. ICS 2 — Industrial Control Devices, Controllers and Assemblies

4. SG 5 — Power Switchgear Assemblies

D. National Fire Protection Association (NFPA):

1. NFPA 70 — National Electric Code

1.03 SUBMITTALS

A. The following submittals shall be made before fabrication:

1. Complete design for the disconnect switch assembly, including all components: disconnect switch, mounting brackets, operating rod and handle.

2. Complete manufacturer's descriptions, catalog data, and information including model number for the disconnect switch.

3. Manufacturer's general and detail arrangement drawings, and installation instructions for the disconnect switch and related accessories.

4. Operation and maintenance manual.

5. List of recommended spare parts.

1.04 QUALITY CONTROL

A. Contractor shall perform the following:

1. Material qualification testing and verification for acceptance of materials, components and assemblies.

2. Job control testing of in-progress work being performed in shops, factories and on-site.

3. On-site inspection of specified work elements.

B. Federal, State and Local Authorities: Conform to applicable codes and regulations.

C. Materials and components manufactured to applicable foreign standards, including metric standards, are acceptable, provided that Contractor submits written evidence, in the English language, that they are equal or superior to those complying with the standards listed in Article 1.02, "Referenced Standards," and written approval is obtained from VTA.

D. Quality Assurance shall be in accordance with the provisions of Special Conditions, Section 6.26 "Quality Assurance and Quality Control Requirements."

1.05 FACTORY TESTS

A. Disconnect switches shall be tested at the factory before shipment, as specified herein. These tests shall be conducted unless the manufacturer can provide documentation satisfactorily to VTA that the tests have been completed previously and the switches have been in operation for the same purpose for 5 years or more.

B. Design Tests: Design tests shall be performed on 1 switch assembly to prove compliance with these technical specifications. Tests shall be conducted generally in accordance with those described in ANSI C37.34, including the following:

1. Dielectric Tests: Impulse and 1-minute AC rms voltages shall be selected assuming a 5 kV (ac) rms rated nominal voltage for the switch.

2. Short-time current test.

3. Mechanical Endurance Test: A completely assembled switch with the actuator rod in the vertical position shall be subjected to 300 open-close cycles at no load. The electrical resistance of main and auxiliary contacts shall be measured before and after this test.

4. Temperature-rise Test: To be carried out immediately after the switch mechanical endurance test, without any adjustments or alignment of the switch proper or the operating linkage.

C. Production Tests: Production tests shall be performed on switch assemblies to check the quality and uniformity of workmanship and materials used. Tests shall include the following:

1. Operation for all components.

2. Power frequency dielectric withstand.

3. Electric resistance of current path.

1.06 MEASUREMENT AND PAYMENT

A. Measurement: DC Disconnect Switches shall be measured by the unit price (EA).

B. Payment:

1. Feeder Disconnect Switch: The contract price paid per unit price (EA) for Feeder Disconnect Switch shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Feeder Disconnect Switch complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

2. Sectionalizing (By-Pass) Disconnect Switch: The contract price paid per unit price (EA) for OCS Sectionalizing (By-Pass) Disconnect Switch shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing OCS Sectionalizing Disconnect Switch complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 GENERAL

A. The DC disconnect switch shall be single-pole, single-throw, no-load, non-fusible type with manual operator. The switch shall be exposed type visible disconnect, suitable for outdoor use and vertical mounting on OCS poles.

B. The DC disconnect switch shall be designed, constructed, and tested in accordance with NEMA, ANSI, and IEEE standards, including the applicable requirements given in ANSI C37.34, ANSI Z55.1, ASTM B187, NEMA 250, NEMA SG 5, NEMA ICS 1, and NEMA ICS 2.

C. The dropping resistor shall be installed in a separate housing as shown on the Plans. The complete resistor assembly shall be able to operate under all weather conditions and ambient temperatures likely to be encountered on the Worksite, and shall require no maintenance.

2.02 RATINGS

A. Disconnect Switch: Switch shall be suitable for 1 kV (dc) operation; its nominal voltage rating shall be not less than 5 kV rms. Continuous current rating shall be 2 kA without exceeding 115°F rise above ambient temperature at the rated current. Momentary current withstand rating shall be not less than 50 kA DC for 5 cycles at 60 Hz.

B. Dropping Resistor: Resistor shall be in the 600 kΩ to 1MΩ range with +/- 20kΩ tolerance. Contractor shall obtain the precise value from the manufacturer, in coordination with VTA. Power rating of the resistor shall be 5W, and nominal voltage rating shall be not less than 8kV (ac) rms.

C. Resistor Housing: The resistor housing assembly, apart from the resistor, shall be designed for a nominal voltage rating of not less than 8kV (ac) rms.

2.03 CONSTRUCTION

A. Manual Operated Disconnect Switch Assembly:

1. Switch shall be furnished with a metal operating rod with a 24-inch insulated fiberglass insert near the top. The operating handle shall be at 48 inches from the finished grade. The operating mechanism at the level of the operating handle, along with the auxiliary contacts for remote switch status indication and devices of the OCS voltage monitoring circuit, shall be enclosed in a 7/64” (12 gage) thick galvanized steel box furnished with a padlock and meeting the requirements of a NEMA 4X enclosure. The width of the enclosure shall not exceed 24 inches. The enclosure shall be furnished with a mounting frame, which in turn shall be banded to the pole. The operating handle shall be outside on the right-hand side. The switch shall be closed when the handle is up, and open when the handle is down. Padlocking provisions shall be provided for both open and closed positions.

2. The stub and the blade of the switch shall be made of copper, and both shall be furnished with silver inserts (soldered or brazed) so that electrical contact is silver to silver. In the closed position of the handle, the operating linkage shall ensure that the switch jaws are held positively in the closed position. Squeezing mechanical pressure shall be exerted on the switch jaws when closed, while the copper parts shall not be used as the pressure-producing mechanism.

3. All non-current carrying metal parts shall be either of hot-dip galvanized steel or of non-ferrous metal.

4. Switch insulators shall be made of porcelain, and shall be sized for nominal voltage of not less than 5 kV (ac) rms.

5. The switch shall be equipped with 4 form-C auxiliary contacts for remote status indication: 2 for "switch-open" status, and 2 for "switch-closed" status. The set of form-C auxiliary contacts for switch open indication shall change status when the operating handle is about 15 degrees away from the "switch-open" position; the set of form-C auxiliary contacts for switch closed indication shall change status when the operating handle is about 15 degrees away from the "switch-closed" position. Auxiliary contacts shall be rated for 10 A at 125 V (dc), and shall be fully enclosed and wired to a suitable terminal block within the overall enclosure for a SCADA wiring termination. Suitable knockouts shall be provided in the enclosure for conduit attachment where required.

6. Disconnect switches equipped with dropping resistor for OCS voltage monitoring shall have a 1 kV (dc), 10 A rated fuse, current-limiting type, installed inside the box at the switch handle. The fuse shall be of the pullout type, and shall serve also as a disconnecting device for the OCS voltage monitoring circuit. Even though the fuse is connected on the low voltage side of the dropping resistor, a sign warning of possible high voltage shall be placed near the fuse end connected to the resistor. A zener diode with a reverse voltage in the 80 V to 95 V range and not less than 5 W power rating shall be provided and connected in series with a regular diode to ground as indicated on the Plans. The regular diode shall have a maximum working voltage of not less than 500 V and nominal current of not less than 1 A.

7. The control cable between the dropping resistor and the fuse in the switch enclosure at the operating handle shall be single conductor, copper, #10 AWG, 2 kV rated, non-shielded cable with EPR insulation and CSPE jacket. The cable shall be installed in a 7/8” diameter GRS conduit along the inside of the pole, with the low end of the conduit connected to the enclosure. The conduit shall be furnished with a weather head on top.

B. Dropping Resistor Housing Assembly. The following describes the baseline design for the resistor housing assembly as a component of the switch assembly. However, Contractor may offer an alternative design, including a different installation concept. Such new design shall at least match the one specified herein in durability, maintainability and safety, and shall be subject to acceptance by VTA. In any case, Contractor shall be responsible for the design, fabrication, and performance of the resistor housing assembly. The optional baseline design is as follows:

1. The housing of the dropping resistor shall be manufactured in accordance with the design concept shown on the Plans. Contractor shall finalize the dimensions where those have been left open or shown as approximate, determine the manufacturing tolerances, and select appropriate materials and accessories where those have not been specified. The end result shall be a durable weatherproof enclosure for the dropping resistor, suitable for all atmospheric conditions and temperatures likely to be encountered on the Worksite.

2. The main components of the resistor housing assembly shall be as follows: The outer shell shall be made of copper water tubing Type K, with an outside diameter of 2 1/8” and an inside diameter of 2”. The copper pipe shall be bare, and shall be closed at the top with a copper cap soldered watertight to the pipe. The bottom of the pipe shall be closed with a specially manufactured plug with an extension that holds the dropping resistor centered inside the pipe. Plug and extension shall be 1 integral piece (referred to as holding plug), and shall be manufactured of Teflon PTFE fluoropolymer; a 2” diameter rod of Teflon PTFE may be used for that purpose. Additional requirements for the resistor housing assembly shall be as shown on the Plans.

3. A lug-style connector shall be brazed to the copper cap (before it has been soldered to the copper pipe) for a vertical connection of the resistor housing assembly to the upper terminal of the switch. The connection shall be to an extension of the upper terminal with an L shape, where the second leg comes down to about 0.67 of the pipe length. The resistor-enclosing pipe shall be fastened at its midpoint to the L-shaped extension by a U-bolt clamp, in addition to its primary lug connection at the top. The clearance between the metallic parts of the resistor housing assembly and parts of the switch at different potential or the OCS pole shall be not less than 1 1/2".

C. Cable Termination: The line and load side terminals of the disconnect switch shall be silver-plated copper pads complying with ASTM B187, suitable to accommodate the number and size of copper cables indicated on the Plans. The switch terminal pads shall be NEMA drilled for cable terminal lugs.

D. Grounding: The operating handle and the enclosure shall have provisions for grounding, and shall be grounded via the OCS pole. The handle shall be grounded to the enclosure. A factory-welded grounding stud shall be provided on the outside back of the enclosure. A welded grounding stud inside the enclosure shall be provided for connection of the zener diode circuit and a general-purpose grounding terminal. Details for grounding the enclosure to the pole or the base plate shall be provided by Contractor, and shall be subject to approval by VTA.

E. ID Label and Warning Signs: Each switch shall be furnished with an ID label and a warning sign made of UV-resistant material.

1. The ID label shall read as follows:

FEEDER DISCONNECT SWITCH xxDxA

or

OCS SECTIONALIZING (BY-PASS) DISCONNECT SWITCH xxDxxx

Where xxDx or xxDxxx is the particular switch designation as shown on the Plans. For substation bypass and OCS sectionalizing switches, the normal switch status N.O. or N.C. shall be added underneath the ID label.

2. The warning for the feeder disconnect type switch shall read as follows:

DO NOT OPERATE SWITCH
IF DC FEEDER BREAKER IS CLOSED

3. The warning for the OCS sectionalizing type switches shall read as follows:

DO NOT OPERATE SWITCH
IF OCS IS ENERGIZED

4. Lettering size, style, and color shall be subject to approval by VTA.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Switches shall be field installed by Contractor at the indicated location, as shown on the Plans and specified herein and in Section 34 23 53, "Overhead Contact System Installation." Special attention shall be given to the orientation of the switch at the indicated location. Switches shall be installed in accordance with the manufacturer's instructions. Contractor shall furnish all mounting hardware.

B. All background and necessary hardware for a complete switch assembly installation, such as clamps, bushings, connectors, supporting frames and brackets, grounding conductors, and all basic electrical materials and hardware needed for the installation of the equipment shall be supplied and installed by Contractor.

C. All auxiliary contacts shall be wired to a properly labeled terminal block inside the overall enclosure.

D. The control cable between the OCS pole and the traction power substation will be furnished and installed under a separate Section of these Technical Specifications, Contractor to terminate control cables to pole-mounted equipment.

E. Before energization of the OCS, Contractor shall verify correct operation of the disconnect switch installed under this Contract, and shall demonstrate the operation of all features to the satisfaction of VTA.

F. The installation shall conform to NFPA 70.

END OF SECTION 34 23 19

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SECTION 34 23 22

OVERHEAD CONTACT SYSTEM KEVLAR ROPE

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for furnishing, delivery, and testing of Kevlar Rope for the Overhead Contact System (OCS), as shown on the Plans, and/or as specified herein.

B. Contractor shall submit details of rope and fittings for each of the required assemblies, based on the performance requirements, working loads, and basic dimensions shown on the Plans and/or as specified herein. The proposed Kevlar Rope shall be subject to acceptance and approval by VTA.

C. The purpose for installation of the Kevlar Rope is as an auxiliary support of the SCAT termination, counterweight and fixed, assemblies. The Kevlar Rope shall comply with General Orders of the State of California Public Utilities Commission (CPUC) for the prevention of catenary wires, contact wire, messenger wire, and parallel feeder cables, falling to the ground in the even of a wire break, insulator or component failure.

1.02 REFERENCED STANDARDS

A. American National Standard Institute (ANSI)

1. C29.1 Test Methods for Electrical Power Insulators.

B. American Society for Testing and materials (ASTM)

1. D885 Standard Test Methods for Tire Cords, Tire Cord Fabrics, and Industrial Filament Yarns Made from Manufactured Organic-Base Fibers

2. D2256 Standard Test method for Tensile Properties of Yarns by the Single-Strand Method

3. D2343 Standard Test method for Tensile Properties of Glass Fiber Strands, Yarns, and Roving Used in Reinforced Plastics.

4. D7269 Standard Test Methods for Tensile Testing of Aramid Yarns

1.03 SUBMITTALS

A. Shop Drawings: Shop drawings shall be submitted before fabrication. Included as a minimum shall be:

1. Physical and electrical characteristics of Kevlar Rope.

2. Catalog Data.

B. Samples: Samples of Kevlar Rope from each manufacturing batch shall be provided in lengths and quantities as requested by VTA or specified in the applicable standards.

C. Certification: A certification shall be furnished by the manufacturer, verifying that the Kevlar Rope has been designed, manufactured, inspected, and tested in accordance with the applicable portions of the referenced standards and these technical specifications.

D. Test Reports: 6 certified copies of manufacturer’s test reports for the Kevlar furnished and any other test reports as may be requested by VTA.

1.04 QUALITY CONTROL

A. Contractor shall perform the following:

1. Material qualification testing and certification for acceptance of materials, components and assemblies.

2. Job control testing of in-progress work being performed in shops, factories and on-site.

3. On-site inspection of specified work elements.

B. Federal, State and Local Authorities: Conform to applicable codes and regulations.

C. Materials and components manufactured to applicable foreign standards, including metric standards, are acceptable, provided that Contractor submits written evidence, in the English language, that they are equal or superior to those complying with the standards listed in Article 1.02, "Referenced Standards", and written approval is obtained from VTA.

D. Quality Assurance shall be in accordance with the provisions of Special Conditions, Section 6.26 “Quality Assurance and Quality Control Requirements.”

1.05 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 – PRODUCTS

2.01 MATERIAL

A. All material shall be of such composition, quality, and purity, that the finished product will have the properties and characteristics described in these technical specifications.

B. The rope shall be made of Aramid Fiber with Polyurethane jacket.

C. The jacket shall be extruded over the aramid fibers and consist of Polyurethane material.

D. Cut or exposed ends shall have a Polyurethane end cap with epoxy resin as supplied by the rope manufacturer applied to and exposed end of rope.

E. The rope shall be terminated by looping it over a thimble and using manufacturer recommended crimping sleeves. Four sleeves per termination shall be employed. Termination shall be done in accordance with manufacturer's instructions.

2.02 PERFORMANCE

A. The physical, mechanical, and electrical properties of the Kevlar Rope shall conform to the requirements of these technical specifications and the pertinent provisions of all standards referenced in this Section.

2.03 INSPECTION AND TESTING

A. VTA reserves the right to witness the manufacture, testing and packing of the Kevlar Rope. The manufacturer shall notify VTA not less than 10 days in advance of manufacturing and testing operations.

B. Kevlar Rope shall be subject to factory quality control tests as required in the applicable standards. Tests shall be performed on each reel before shipment. A certified copy of the test report for each reel shall be submitted to VTA before shipment. A copy of the test report shall be packaged with each reel.

C. The mechanical strength shall meet or exceed the strength indicated on the manufacturer's published data.

D. Electrical insulation shall have a flashover and leakage current test performed on a 24-inch long specimen of the rope.

2.04 PACKAGING AND MARKING

A. Kevlar Rope shall be shipped in reels, suitable for the weight of the rope and the rope shall be protected from injury.

B. Each reel shall have a strong weatherproof tag securely fastened to it, showing the physical, mechanical, and electrical properties as well as type designation, ASTM designation, the name and mark of the manufacturer, the purchase order number, and the component number.

C. Each rope length shall bear the manufacturer's name or trademark, catalog number, and size clearly and permanently imprinted, without affecting the appearance or the function of the item. Printing shall be spaced every 2 feet.

PART 3 – EXECUTION

A.01 INSTALLATION REQUIREMENTS

A. Insulator installation is covered in Section 34 23 53, "Overhead Contact System Installation," of these technical specifications.

END OF SECTION 34 23 22

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SECTION 34 23 23

OVERHEAD CONTACT SYSTEM BARE CONDUCTORS

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for the overhead traction power cables or conductors used in the Overhead Contact System (OCS) as messengers, contact wire, parallel feeder cables, jumpers, bare feeders, and ground wire as shown on the Plans and specified herein.

B. Conductor installation is specified in Section 34 23 53, "Overhead Contact System Installation," of these technical specifications.

1.02 REFERENCED STANDARDS

A. American Society for Testing and materials (ASTM):

1. ASTM B1 Standard Specification for Hard-Drawn Copper Wire.

2. ASTM B3 Standard Specification for Soft or Annealed Copper Wire.

3. ASTM B8 Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium- Hard, or Soft.

4. ASTM B47 Standard Specification for Copper Trolley Wire.

1.03 SUBMITTALS

A. Shop Drawings: Shop drawings shall be submitted before fabrication. Included as a minimum shall be:

1. Physical and electrical characteristics of conductors.

2. Catalog data.

B. Samples: Samples of conductors from each manufacturing batch shall be provided in lengths and quantities requested by VTA or specified in the applicable standard.

C. Certification: A certification shall be furnished by the manufacturer, verifying that the conductors have been designed, manufactured, inspected and tested in accordance with applicable portions of the referenced standards and these technical specifications.

D. Test Reports: 6 certified copies of manufacturer's test reports for the specific conductors furnished and any other test reports as may be requested by VTA.

E. Creep data verification tests and creep data for not less than 1000 hours shall be furnished for all conductors supplied by the manufacturer.

F. Splicing Method: Submit method of factory splicing contact wire.

1.04 QUALITY CONTROL

A. Contractor shall perform the following:

1. Material qualification testing and certification for acceptance of materials, components and assemblies.

2. Job control testing of in-progress work being performed in shops, factories and on-site.

3. On-site inspection of specified work elements.

B. Federal, State and Local Authorities: Conform to applicable codes and regulations.

C. Materials and components manufactured to applicable foreign standards, including metric standards, are acceptable, provided that Contractor submits written evidence, in the English language, that they are equal or superior to those complying with the standards listed in Article 1.02, "Referenced Standards", and written approval is obtained from VTA.

D. Quality Assurance shall be in accordance with the provisions of Special Conditions, Section 6.26 “Quality Assurance and Quality Control Requirements.”

1.05 MEASUREMENT AND PAYMENT

A. OCS Bare Conductors - SCAT: The contract price paid per unit price (LF) for Overhead Contact System Bare Conductors (Contact and Messenger Wire) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Overhead Contact System Bare Conductors (Contact and Messenger Wire) complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

B. OCS Bare Conductors - PF: The contract price paid per unit price (LF) for Overhead Contact System Bare Conductors (Parallel Feeder Cables) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Overhead Contact System Bare Conductors (Parallel Feeder Cables) complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

C. OCS Jumper Assemblies: The contract price paid per unit price (EA) for Jumper Assemblies shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Jumper Assemblies complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 MATERIALS

A. All material shall be of such composition, quality, and purity, that the finished product will have the properties and characteristics described in these technical specifications.

B. Conductor materials shall be of the following types:

1. Contact Wire: 350 kcmil hard drawn copper cable, solid grooved, conforming to ASTM B47.

2. Messenger Wire: 500 kcmil hard drawn copper cable, 19-strand, conforming to ASTM B1 and ASTM B8, Class AA, bare.

3. Parallel Feeder: 1000 kcmil aluminum (AAC/TW) cable, 31-strand, conforming to ASTM B230 and ASTM B778, bare.

4. Equalizing Jumpers: 350 kcmil annealed copper cable, 259-strands, conforming to ASTM B3 and ASTM B8, Class G, bare.

5. Continuity Jumpers: 350 kcmil annealed copper cable, 259-strand, conforming to ASTM B3 and ASTM B8, Class G, bare.

6. Ground Wire:

   a. Pole Grounding: 4/0 annealed copper conductor, bare, Class B, 19-strand, conforming to ASTM B3 and ASTM B8.

2.02 PERFORMANCE

A. The physical, mechanical and electrical properties of the conductors shall conform to the requirements of these technical specification and the pertinent provisions of all standards referenced in this Section.

2.03 INSPECTION AND TESTING

A. VTA reserves the right to witness the manufacture, testing and packing of all conductors. The manufacturer shall notify VTA not less than 10 days in advance of manufacturing and testing operations.

B. All conductors shall be subject to factory quality control tests as required in the applicable standards. Tests shall be performed on each reel before shipment. A certified copy of the test report for each reel shall be submitted to VTA before shipment. A copy of the test report shall be packed with each reel.

C. Grooved contact wire supplied in accordance with ASTM B47 shall be subject to the ASTM B47 twist test in addition to other required tests. The twist test shall be performed as specified for round wire, except that 6 twists shall be required. Contact wire not meeting this test will be rejected.

D. Contact wire factory splices shall be free of any kinks and shall be marked with a bright paint for visual check and identification. The method of splicing shall be submitted to VTA for approval.

2.04 PACKAGING AND MARKING

A. All conductors shall be shipped on reels, suitable for the weight of the conductors and the conductors shall be protected from injury. The diameter of reels shall be sufficiently large to eliminate difficulty with waves or kinks when the conductor is strung.

B. Each reel shall have a strong weatherproof tag securely fastened to it, showing the physical, mechanical, and electrical properties as well as type designation, ASTM designation, the name and mark of the manufacturer, the purchase order number, and the component number.

C. Messenger wire, contact wire, and parallel feeder cable shall be packed so that no field splices are required in the tension sections as installed. Each reel shall be suitable for the conductor type and its cut length/weight, with the conductor in one continuous length.

D. Contact wire reels shall be packed with the vertical axis of the wire perpendicular to the axis of the reel, with the contact surfaces facing inward and the top (grooved) side outward.

PART 3 – EXECUTION

3.01 GENERAL

A. Contractor shall verify all related cable lengths in the field before placing any order.

3.02 INSTALLATION REQUIREMENTS

A. Conductor installation is covered in Section 34 23 53, "Overhead Contact System Installation," of these technical specifications.

END OF SECTION 34 23 23

SECTION 34 23 26

SPECIAL TOOLS

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for Special Tools required for the work, including height/stagger gauges, super-elevation/step gauges, grounding jumpers, live line tools, hoists, computers, etc.

B. General Requirements:

1. Traction Power Substations. One complete set of special tools such as rocking handles, third wheels, etc., required for the maintenance of the substation equipment shall be furnished for each substation. A complete list of the special tools shall be provided, and the cost of the tools shall be included in the prices for the equipment to be furnished.

2. Overhead Contact System. One complete set of special tools such as height/stagger gauges and super-elevation/step gauges, shall be procured or fabricated by the Contractor in accordance with the performance requirements specified herein. All other materials and equipment items shall be standard manufactured items, as hereinafter specified, unless otherwise noted.

3. All special tools specified herein shall be used by the Contractor and shall remain his property, throughout the construction period of the TPSS and OCS and during its subsequent testing and commissioning as specified in Sections 34 21 63 (TPSS Testing and Commissioning) and Section 34 23 69 (OCS and TES Interface Testing and Commissioning). Following acceptance of all segments of the completed system, all gauges and special tools (except for consumable items) shall become the property of VTA and shall be delivered to VTA in good working condition, as directed.

1.02 RELATED SECTIONS

A. Section 01 33 00 – Submittal Procedures

B. Section 01 42 13 – Abbreviations and Acronyms

C. Section 01 78 43 – Spare Parts

D. Section 34 21 16 – Traction Power Substations

E. Section 34 21 53 – Traction Power Substation Field Installation

F. Section 34 21 63 – TPSS Testing and Commissioning

G. Section 34 23 53 – Overhead Contact System Installation

H. Section 34 23 63 – OCS and TES Interface Testing and Commissioning

1.03 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures.

B. Submit list, catalog sheets and shop drawings showing details and dimensions of all special tool products and assemblies together with complete specifications of materials.

C. Certified statements and documents shall be submitted verifying that the height/stagger gauges and super-elevation/step gauges conform to the performance requirements.

D. Submit operating instructions and procedures in handling the special tools.

1.04 MEASUREMENT AND PAYMENT

A. Measurement: Special Tools shall be measured by the lump sum (LS) price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum (LS) payment for Special Tools shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Special Tools complete in place, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 MATERIALS

A. All materials proposed for use shall meet the applicable performance requirements and shall be non-corrosive and durable.

B. Guy ropes shall be of synthetic materials.

C. Height/stagger gauges and super-elevation/step gauges shall be fabricated from aluminum alloy sections, or approved material, and shall be 2000 V cross track insulation to maintain track polarity and provide no interference with track circuits during gauging.

2.02 NOTEBOOK COMPUTERS

A. Description: Two new commercially available personal notebook type computers (latest Intel processor, or equal with 512 MB RAM minimum) with accessories, software (operating and equipment specific) and hardware manuals, carrying cases and ink jet type portable printers shall be furnished for communicating with the thyristor digital control system. It shall be used for programming and downloading programs, checking parameters and signal values, etc. Two fully equipped units shall be supplied with the first shipment.

2.03 HEIGHT/STAGGER GAUGES

A. General: Each height/stagger gauge shall include two interchangeable gauge heads to be used to measure heights and staggers and electrical clearances of the catenary system when the system is not energized.

B. Description:

1. Height/stagger gauges shall be compact, lightweight construction, rigidly mounted on rail vehicles without springs or side play and shall be designed to simulate the dynamic profile

envelope of the pantograph as specified on the Contract Documents. The Contractor shall have the option of providing each gauge with a mechanical tilting and/or linkage system to simulate the dynamic envelope or providing a simplified fixed profile envelope gauge with attachments that provide an equivalent simulation. The Contractor shall submit data on the estimated level of variance from the theoretical values to VTA for review and approval. In addition to measuring the contact wire height and stagger, the height/stagger gauges shall be designed to measure the following:

a. Pantograph sway from top of LRV

b. Cross-track level tolerance

c. Cross-track displacement of LRV and level tolerance

d. Contact wire uplift

e. Combined mechanical and electrical clearance from pantograph dynamic outline envelope

2. Weight: The height/stagger gauges shall be lightweight, for handling by two men in lifting the gauges off the track or placing them on top of the super-elevation/step gauges.

3. Fabrication: Height/stagger gauges shall be fabricated and assembled as approved shop drawing submittals.

4. Strength: The height/stagger gauges shall be strong enough to withstand light impact loads, normal handling and use procedures, under moderate (30 mph) wind conditions, without deflection, buckling or permanent deformation.

5. Adjustability: The height/stagger gauges shall be easily adjustable for calibration purposes.

6. Readability: The height/stagger gauges shall be readable with 20-20 vision within a distance of 30 feet.

7. Vertical Operating Range: The height/stagger gauges shall be capable of measurement over a contact wire height range of from 13 feet to 24.5 feet.

8. Quantities: Provide two (2) height/stagger gauge assemblies including 2 stagger gauge heads and 2 pantograph gauge heads.

2.04 SUPER-ELEVATION/STEP GAUGES

A. General: Super-elevation/step gauges shall be used for purposes of adjusting the inclination of the height stagger gauge by placing the step gauge on the rail under the height/stagger gauge.

B. Description: Super-elevation/step gauges shall be used to evaluate the actual track super-elevation for the purpose of adjusting the position of the contact wires.

C. Adjustability: Super-elevation/step gauges shall be designed for use with a calibrated spirit level system, with the levels placed crosswise on the top surfaces or steps of the gauges for direct reading.

D. Readability: Spirit levels to be used with super-elevation/step gauges shall be calibrated in mm and easily readable with 20-20 vision with distance of 5 feet.

E. Quantities: Provide two (2) super-elevation/step gauges.

PART 3 – EXECUTION

3.01 GENERAL REQUIREMENTS

A. Fabrication and assembly procedures shall not start until the required submittals have been reviewed and approved.

B. The Contractor shall deliver the assembled products complete and ready for use to the VTA in sufficient time for catenary adjustment purposes.

C. The Contractor shall be responsible for and protect all products from damage during the duration of the project, and shall deliver all gauges in good working condition to VTA at the acceptance and completion of the project.

END OF SECTION 34 23 26

SECTION 34 23 33

GALVANIZED STEEL WIRE AND WIRE ROPE

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for all grades of galvanized steel wire, pre-forms and wire rope for use as support wires and guys for the Overhead Contact System (OCS), as shown on VTA LRT Standard Detail Manual or the Plans and specified herein.

B. Installation of galvanized steel wire and wire rope is specified under Section 34 23 53, "Overhead Contact System Installation," of these technical specifications.

1.02 REFERENCED STANDARDS

A. American Society for Testing and Materials (ASTM):

1. A475 Standard Specifications for Zinc-Coated Steel Wire Strand

1.03 SUBMITTALS

A. Six certified copies of reports containing the physical and mechanical properties of all components described in this Section shall be submitted. Test reports shall be included. The conformance of components with these technical specifications and VTA LRT Standard Detail Manual and the Plans in the form of a manufacturer's product data, tests and certification shall be included.

1.04 QUALITY CONTROL

A. Contractor shall perform the following:

1. Material qualification testing and certification for acceptance of materials, components and assemblies.

2. Job control testing of in-progress work being performed in shops, factories and on-site.

3. On-site inspection of specified work elements.

B. Federal, State and Local Authorities: Conform to applicable codes and regulations.

C. Materials and components manufactured to applicable foreign standards, including metric standards, are acceptable, provided that Contractor submits written evidence, in the English language, that they are equal or superior to those complying with the standards listed in Article 1.02, "Reference Standards," and written approval is obtained from VTA.

D. Quality Assurance shall be in accordance with the provisions of Special Conditions, Section 6.26 “Quality Assurance and Quality Control Requirements.”

1.05 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 – PRODUCTS

2.01 DESCRIPTION

A. Components: The zinc-coated stranded wire shall be manufactured and tested in accordance with ASTM A475.

B. Performance: Physical properties of the zinc-coated stranded wire shall conform to the description in ASTM A475, Table 1.

C. Materials: The material used for stranded steel wire shall conform to ASTM A475.

D. Zinc Coating: The weight of coating for zinc-coated steel wire shall not be less than that specified in ASTM A475, Table 4, Class C.

2.02 TYPES

A. Galvanized steel wire rope shall be of the following types:

1. Headspan and Cross Span Wires, Cantilever Top Ties: 5/16” diameter, extra high-strength grade.

2. Deadends and head guys: 1/2” diameter, high-strength grade.

3. Down Guys: 5/8” and 3/4" diameter, high-strength grade.

2.03 CERTIFICATION

A. Contractor shall provide certification that the galvanized steel wire and wire rope have been designed, fabricated, rated and tested in compliance with the applicable provisions of the standards referenced in these technical specifications.

PART 3 – EXECUTION

3.01 DELIVERY AND MARKING

A. Materials shall be protected against damage in ordinary handling and shipping. Each reel shall have a strong, weatherproof tag securely fastened to it showing the physical and mechanical properties as well as the steel type designation, ASTM designation and the name and mark of the manufacturer.

3.02 INSTALLATION REQUIREMENTS

A. Galvanized steel wire and wire rope installation is covered in Section 34 23 53, "Overhead Contact System Installation," of these technical specifications.

END OF SECTION 34 23 33

SECTION 34 23 36

STAINLESS STEEL WIRE AND WIRE ROPE

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for stainless steel wire and wire rope for use as hangers and support wires for the Overhead Contact System (OCS), as shown on VTA LRT Standard Detail Manual, the Plans, and specified herein.

B. Installation of stainless steel wire and wire rope is specified under Section 34 23 53, "Overhead Contact System Installation," of these technical specifications.

1.02 REFERENCED STANDARDS

A. American Society for Testing and Materials (ASTM):

1. A368 — Standard Specification for Stainless Steel Wire Strand
2. A492 — Standard Specification for Stainless Steel Rope Wire
3. A493 — Standard Specification for Stainless Steel Wire and Wire Rods for Cold Heading and Cold Forging
4. A555/A555M — Standard Specification for General Requirements for Stainless Steel Wire and Wire Rods.

1.03 SUBMITTALS

A. Six certified copies of reports containing the physical and mechanical properties of all components described in this Section shall be submitted. Test reports shall be included. The conformance of components with these technical specifications, VTA LRT Standard Detail Manual or the Plans in the form of a manufacturer's product data, tests and certification shall be included.

1.04 QUALITY CONTROL

A. Contractor shall perform the following:

1. Material qualification testing and certification for acceptance of materials, components and assemblies.
2. Job control testing of in-progress work being performed in shops, factories and on-site.
3. On-site inspection of specified work elements.

B. Federal, State and Local Authorities: Conform to applicable codes and regulations.

C. Materials and components manufactured to applicable foreign standards, including metric standards, are acceptable, provided that Contractor submits written evidence, in the English language, that they are equal or superior to those complying with the standards listed in Article 1.02, "Reference Standards," and written approval is obtained from VTA.

D. Quality Assurance shall be in accordance with the provisions of Special Conditions, Section 6.26 “Quality Assurance and Quality Control Requirements.”

1.05 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 – PRODUCTS

2.01 DESCRIPTION

A. Solid stainless steel wire shall be manufactured and tested in accordance with ASTM A493 and ASTM A555/A555M. Stainless steel wire rope shall be composed of a multiplicity of round wires manufactured and tested in accordance with ASTM A555/A555M, ASTM A368, and ASTM A492.

2.02 MATERIAL

A. The physical and mechanical properties of the stainless steel wire rope and solid stainless steel wire shall conform to the appropriate tables of the ASTM standards referenced in Article 1.02A of this Section. Stainless steel wire shall be Type 304.

2.03 TYPES

A. Stainless steel wire and wire rope shall be of the following types:

1. Cantilever Arm, Registration Pipe Support: 1/4” diameter. 7 x 19 construction, 6400 LBS breaking strength.

2. Hangers: 1/4” diameter, 7 x 19 construction, 6,400 LBS breaking strength.

3. Counterweight Support Cables: 1/2” diameter, non-spinning cable, 19 x 7 construction, 20,520 LBS breaking strength.

2.04 CERTIFICATION

A. Contractor shall provide certification that the stainless steel wire and wire rope products have been designed, fabricated, rated and tested in compliance with the applicable provisions of the standards referenced in these technical specifications.

PART 3 – EXECUTION

3.01 DELIVERY AND MARKING

A. Materials shall be protected against damage in ordinary handling and shipping. Each reel shall have a strong, weatherproof tag securely fastened to it showing the physical and mechanical properties as well as steel type designation, ASTM designation and the name and mark of the manufacturer.

3.02 INSTALLATION REQUIREMENTS

A. Stainless steel wire and wire rope installation is covered in Section 34 23 53, "Overhead Contact System Installation," of these technical specifications.

END OF SECTION 34 23 36

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SECTION 34 23 39

OVERHEAD CONTACT SYSTEM ASSEMBLIES, COMPONENTS, AND FITTINGS

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for assemblies, fittings and components for counterweight and fixed end terminations, cantilevers, registration arms, pull offs/push offs, down guys, headspans, cross spans, and other components required as part of the Overhead Contact System (OCS) components, as shown on the Plans and specified herein.

B. Contractor shall perform final design of assemblies to ensure proper intended function and fit, and shall submit details of the components for each of the required assemblies, based on the performance requirements, working loads and basic dimensions as shown on the Plans and as specified herein. The components proposed for the assemblies shall meet all dimensional and performance criteria, provide an aesthetically pleasing, low profile aspect, and shall be subject to approval and acceptance by VTA.

C. The OCS assemblies shall comply with the General Orders of the State of California Public Utilities Commission (CPUC), particularly the requirement for double insulation. All OCS support assemblies shall clear the pantograph dynamic envelope.

D. All OCS equipment is energized at a nominal 750 Vdc and shall be double insulated.

E. Installation of assemblies, fittings and hardware is specified in Section 34 23 53, "Overhead Contact System Installation," of these technical specifications.

1.02 REFERENCED STANDARDS

A. American Society for Testing and Materials (ASTM):

1. A47/A47M Standard Specification for Ferritic Malleable Iron Castings.
2. A153/A153M Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
3. A518/A518M Standard Specification for Corrosion-Resistant High-Silicon Iron Castings.
4. A536 Standard Specification for Ductile Iron Castings.
5. A668/A668M Standard Specification for Steel Forgings, Carbon and Alloy, for General Industrial Use.
6. A711 Standard Specification for Steel Forging Stock.
7. B29 Standard Specification for Refined Lead.
8. B148 Standard Specification for Aluminum-Bronze Sand Castings.

9. B248 Standard Specification for General Requirements for Wrought Copper and Copper-Alloy Plate, Sheet, Strip, and Rolled Bar.

10. B249/B249M Standard Specification for General Requirements for Wrought Copper and Copper-Alloy Rod, Bar, Shapes and Forgings.

11. B584 Standard Specification for Copper Alloy Sand Castings for General Applications.

1.03 SUBMITTALS

A. Refer to Special Conditions for submittal requirements and procedures.

B. The following submittals shall be made before fabrication:

1. Shop Drawings: Fully dimensioned drawings of all components and assemblies. Shop assembly and outline drawings of all equipment specially manufactured for this Contract including separate drawings for each style of Cantilever assembly showing lowest value dimensions for pole offsets and typical track super-elevations. Each typical cantilever assembly drawing shall show the pantograph clearance envelope on the super-elevated track centerline at contact wire level. The pantograph clearance envelope shall be as shown in the Plans. All assemblies shall be supported by calculations to confirm adequacy and ability to meet working loads.

2. Product Data Samples: Manufacturers catalog cuts and data sheets, and samples as required by VTA.

3. Certifications and Test Reports: Material, tests and certifications for each individual component and demonstration tests as required with test reports for complete assemblies.

1.04 QUALITY CONTROL

A. Federal, State and Local Authorities: Conform applicable codes and regulations.

B. Materials and components manufactured to applicable foreign standards, including metric standards, are acceptable, provided that Contractor submits written evidence, in the English language, that they are equal or superior to those complying with the standards listed in Article 1.02, "Reference Standards," and written approval is obtained from VTA.

C. Quality Assurance shall be in accordance with the provisions of Special Conditions, Section 6.26 “Quality Assurance and Quality Control Requirements.”

1.05 MEASUREMENT AND PAYMENT

A. Full compensation for providing OCS Assemblies, Components, and Fittings shall be considered as included in the bid items in Section 34 23 53 "Overhead Contact System Installation," and no additional compensation will be allowed therefore.

PART 2 – PRODUCTS

2.01 DESCRIPTION

A. Material for fittings shall comply with VTA LRT Standard Detail Manual or the Plans and the applicable Standards referenced in these technical specifications. Substitutions will be considered if the requirements of the Contract Documents are satisfied.

2.02 METAL CHARACTERISTICS

A. Malleable Iron: Fittings or components made of malleable iron shall be Grade 32510 or better, and shall conform to ASTM A47/A47M. All components and fittings shall be galvanized in accordance with ASTM A153/A153M.

B. Forged Steel: Material for forged steel shall comply with AISI Types C-1035 to C-1045 SBQ and ASTM A711 or ASTM A668/A668M. All components and fittings shall be galvanized in accordance with ASTM A153/A153M.

C. Cast Iron: Cast iron weights and counterweights, if used, shall be of corrosion-resistant, high-silicon cast iron, in accordance with ASTM A518/A518M. Alternatively, lead or concrete weights and counterweights may be supplied by Contractor, if accepted by VTA.

D. Ductile Iron: Fittings or components requiring higher yield strength shall be of ductile iron, Grade 60.40.18 or better, and shall conform to ASTM A536. All fittings and components shall be galvanized in accordance with ASTM A153/A153M.

E. Stainless Steel: Stainless steel hardware shall be AISI Types 302 or 304.

F. Non-Ferrous Metals: Copper alloys for fittings and components shall comply with ASTM B584 and ASTM B148.

G. Copper: All copper components shall conform to ASTM B248 or ASTM B249/B249M.

H. Copper-Clad: Grounding components shall be the manufacturer's standard items and shall conform to the IEEE definition of copper-clad materials.

I. Lead: Lead for balance weights in counterweight assemblies shall be casting grade, conforming to ASTM B29.

2.03 MANUFACTURE AND PERFORMANCE

A. The designated metals shall be produced by an approved method that will meet the requirements of the ASTM standards and these technical specifications.

B. Castings shall be of uniform quality and shall be made in such a manner that the material of the casting conforms to the chemical and mechanical properties prescribed in the applicable ASTM standards.

2.04 SAMPLING AND TESTING

A. For tension tests, a minimum of 3 test bars shall be poured from each lot of metal. Tests shall be performed on all termination fittings.

B. For chemical analysis, each lot of castings shall be analyzed for conformance with the chemical composition specified in the ASTM standards.

C. A lot shall consist of all castings produced from 1 furnace melt.

2.05 WORKMANSHIP, FINISH, AND APPEARANCE

A. The castings shall be free of adhering sand, visual cracks, surface porosity and shrinkage.

B. Contractor shall be responsible for the dimensional accuracy of castings and forgings.

C. Casting repairs shall be permitted only to the extent allowed by ASTM standards. If welding or repair of a greater magnitude is required, Contractor shall obtain the acceptance of VTA before proceeding.

2.06 MARKING AND SHIPPING

A. The identification mark of the foundry and the pattern numbers assigned by the supplier shall be cast into all castings, of sufficient size, in such a position that they will not interfere with the further processing and serviceability of the casting.

B. Castings shall be packed in accordance with the best commercial practice, adequate to ensure acceptance and safe delivery.

PART 3 – EXECUTION

3.01 INSTALLATION REQUIREMENTS

A. Installation of assemblies, fittings and hardware is covered under Section 34 23 53, "Overhead Contact System Installation," of these technical specifications.

END OF SECTION 34 23 39

SECTION 34 23 43

FASTENERS

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for varies types of fasteners (bolts, nuts, and washers) for general use and structural connections on the Overhead Contact System (OCS), as shown on VTA LRT Standard Design Manual, the Plans, and as specified herein.

B. Installation of fasteners is specified in Section 34 23 53, "Overhead Contact System Installation," of these technical specifications.

1.02 REFERENCED STANDARDS

A. U.S. Department of Transportation, Federal Highway Administration (FHWA):

1. Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects, herein after referred to as the "FHWA Standard Specifications."

B. American Society for Testing and Materials (ASTM):

1. A153/A153M — Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
2. A307 — Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength.
3. A325 — Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 KSI Minimum Tensile Strength.
4. A449 — Standard Specification for Quenched and Tempered Steel Bolts and Studs.
5. A563 — Standard Specification for Carbon and Alloy Steel Nuts.
6. F436 — Standard Specification for Hardened Steel Washers.
7. F467 — Standard Specification for Nonferrous Nuts for General Use.
8. F468 — Standard Specification for Nonferrous Bolts, Hex Cap Screws, and Studs for General Use.
9. F593 — Standard Specification for Stainless Steel Bolts, Hex Cap Screws and Studs.
10. F594 — Standard Specification for Stainless Steel Nuts.

C. American Society of Mechanical Engineers

1. ASME B18.16.6 Prevailing Torque Locknuts

1.03 SUBMITTALS

A. Test Reports: 6 certified copies of all field tests reports shall be submitted to VTA as required or recommended by these technical specifications and applicable standards, or as necessary to establish compliance with the Contract Documents.

1.04 QUALITY CONTROL

A. Federal, State and Local Authorities: Conform to applicable codes and regulations.

B. Materials and components manufactured to applicable foreign standards, including metric standards, are acceptable, provided that Contractor submits written evidence, in the English language, that they are equal or superior to those complying with the standards listed in Article 1.02, "Reference Standards," and written approval is obtained from VTA.

C. Quality Assurance shall be in accordance with the provisions of Special Conditions, Section 6.26 "Quality Assurance and Quality Control Requirements."

1.05 INSTALLATION REQUIREMENTS

A. Fasteners shall be installed in accordance with VTA LRT Standard Detail Manual and the Plans.

B. All nuts and studs shall be torqued to the manufacturer's recommendation, using an indicating torque wrench.

1.06 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Ferrous Metal Fasteners:

1. Material: The material for ferrous metal fasteners shall comply with the applicable portions of the referenced standards.

2. Anchor Bolts: Anchor bolts used for anchoring structures to their foundation shall comply with ASTM F1554 GR55. Nuts shall comply with ASTM A563, Grade D and flat washers shall comply with ASTM F436.

3. Structural Joint and Fitting Connections: Ferrous fasteners used with structural connections and fittings shall comply with ASTM A325.

4. U-Bolt and Stud Connections: U-bolts and studs shall comply with ASTM A449. Washers shall comply with ASTM F436, and nuts shall comply with ASTM A563, Grade B.

5. Boxbolts (Blind Bolts): Boxbolts to be high tensile grade and shall comply with ASTM A325.

6. Galvanizing: Ferrous fasteners shall be galvanized in accordance with ASTM A153/A153M, Grade C.

B. Stainless Steel Fasteners:

1. Stainless steel bolts, screws, studs, locknuts, and nuts shall be used for connections between ferrous and nonferrous metals, and in other applications where shown on VTA LRT Standard Detail Manual and the Plans.

2. Stainless steel bolts, screws and studs shall comply with ASTM F593. Stainless steel nuts shall comply with ASTM F594.

C. Nonferrous Metal Fasteners:

1. Nonferrous metal fasteners shall be manufactured from material conforming to the applicable portions of the referenced standards.

2. Nonferrous bolts and studs shall comply with ASTM F468. Nonferrous nuts shall comply with ASTM F467. Nonferrous washers and lockwashers shall be the manufacturer's standard product.

2.02 BOLTED CONNECTIONS

A. Bolted connections using standard fasteners in accordance with ASTM A307 shall conform to the applicable requirements of Subsection 555.10 of the FHWA Standard Specifications.

B. Bolted connections using high tensile strength bolts in accordance with ASTM A325 shall conform to the applicable requirements of Subsection 555.11 of the FHWA Standard Specifications.

2.03 GALVANIZING

A. Bolts, locknuts, nuts, washers, anchors and other items of iron or steel hardware shall be hot-dipped galvanized as follows:

1. Perform galvanizing in accordance with ASTM A153/A153M, as applicable. The weight of the zinc coating shall be not less than 1.25 oz/ft^2 of surface area.

2. Threads of nuts shall be re-tapped after galvanizing. Bolts and nuts shall be assembled immediately after the re-tapping of nuts to retard corrosion of uncoated female threads.

3. Hardware items furnished already galvanized shall be delivered with the necessary certificates of conformance with ASTM A153/A153M and the required zinc coating specified.

2.04 MANUFACTURE AND PERFORMANCE

A. Fasteners shall be produced by any method that will meet the requirements of ASTM standards and this technical specification.

2.05 TESTING

A. Fasteners shall be tested in accordance with the ASTM mechanical testing requirements for the applicable type, length of product and minimum tensile strength.

2.06 MARKING

A. Bolts shall be marked according to ASTM standards.

2.07 SOURCE QUALITY CONTROL

A. The fastener manufacturer shall provide a certified copy of the latest test report for each stock size in each shipment.

B. Fasteners shall be shipped in sturdy boxes that are clearly marked with the manufacturers name, lot number, purchase order number, size and material.

PART 3 – EXECUTION

3.01 INSTALLATION REQUIREMENTS

A. Fasteners shall be installed in accordance with VTA LRT Standard Detail Manual and the Plans.

B. All nuts and studs shall be torqued to the manufacturer's recommendation, using an indicating torque wrench.

END OF SECTION 34 23 43

SECTION 34 23 46

SECTION INSULATORS

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for bridging type Section Insulator assemblies for the Overhead Contact System (OCS), as shown on the Plans and specified herein.

B. Contractor shall submit details of the components for each of the required assemblies, based on the conductor tensions and electrical stresses shown on VTA LRT Standard Detail Manual or the Plans. The basic dimensions of the section insulators shall be as recommended by the manufacturer. Contractor's proposed assemblies and applications shall be subject to approval and by VTA.

C. Section insulator assembly installation is specified in Section 34 23 53, "Overhead Contact System Installation," of these technical specifications.

1.02 REFERENCED STANDARDS

A. State of California Public Utilities Commission (CPUC):

1. G.O. 95 Rules for Overhead Electric Line Construction.

1.03 SUBMITTALS

A. Shop Drawings: Shop drawings shall be submitted before fabrication. Included as a minimum, shall be:

1. Insulators:

a. Electrical:

1) Attachment centers or overall length (in).

2) Shed diameters (in).

3) Core diameters (in).

b. Mechanical:

1) Attachment centers or overall length (in).

2) Shed diameters (in).

3) Core diameters (in).

4) Breakdown of weights, insulator and fittings (LB).

5) Tensile withstand load (LBS).

6) Recommended maximum working tensile load (LBS).

7) Material (including end caps and touch-up insulator sealants).

2. Manufacturer's design safety factors.

3. Drawings of hardware and components.

4. Listing and description of components and hardware.

5. Drawings and specifications required for field forming and setting of contact wire into items, including gliders.

6. For assemblies, list Values of BIL, ultimate tensile strengths, ultimate torsional strength, weights (including weight of components) and electrical characteristics.

B. Instruction Manual: Instruction manuals shall be furnished covering complete instructions for installation, maintenance and testing. Complete replacement parts lists shall be included.

C. Test Reports: 6 certified copies of reports of the following tests should be furnished:

1. Prototype tests.

2. Production tests.

3. Field tests.

D. The manufacturer shall submit full information, with supporting documentation, on the in-service history of the section insulators to be furnished in accordance with these technical specifications.

1.04 QUALITY CONTROL

A. Contractor shall perform the following:

1. Material qualification testing and certification for acceptance of materials, components and assemblies.

2. Job control testing of in-progress work being performed in shops, factories and on-site.

3. On-site inspection of specified work elements.

B. Federal, State and Local Authorities: Conform to applicable codes and regulations.

C. Materials and components manufactured to applicable foreign standards, including metric standards, are acceptable, provided that Contractor submits written evidence, in the English language, that they are equal or superior to those complying with the standards listed in Article 1.02, "Reference Standards," and written approval is obtained from VTA.

D. Quality Assurance shall be in accordance with the provisions of Special Conditions, Section 6.26 “Quality Assurance and Quality Control Requirements.”

1.05 MEASUREMENT AND PAYMENT

A. Measurement: Section Insulators shall be measured by the unit price (EA).

B. Payment: The contract price paid per unit price (EA) for Section Insulators shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Section Insulators complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 DESCRIPTION

A. Section insulator assemblies shall be as shown on the Plans and shall be service-proven units. Section insulators shall be capable of providing smooth current collection without interruption for pantographs running at a speed of up to 55 mph maximum for SCAT installation. The section insulators shall meet or exceed the following design requirements:

1. The design of section insulators shall be for SCAT system or as shown on the Plans.

2. The design shall ensure that electrical separation between catenary wires of adjacent sections is maintained at all times, electrically isolating one section from the other.

3. The section insulator shall be designed to remain stable (dynamically and structurally) under sustained crosswinds of 55 mph.

4. The section insulator shall be designed to withstand crosswinds of up to 75 mph without failure, including permanent deformation.

5. The design shall ensure smooth passage of the pantograph across the section insulator. Tilting during pantograph passage shall not be so severe as to damage pantograph contact surfaces. The skids shall be set as high as possible, consistent with ensuring that the pantograph does not strike the runners. Allowance shall be made for the springiness of the skids on impact of a fast-moving pantograph. The section insulator shall be free of "hard spots."

6. The design shall ensure that the moving pantograph is always in contact with the section insulator runners/skids.

7. The section insulator shall be positioned close to a supporting structure as shown on the Plans, with the central point close to the centerline of a static pantograph. The midspan offset of the contact wire shall be within limits acceptable to VTA.

8. The spacing of the runners/skids on the section insulator shall be such that both sides are always in contact with the working portion of the pantograph.

9. Where the design does not require continuity, the section insulator shall be fitted with suitable arc traps/extinguishers. The traps/extinguishers shall be placed as recommended by the manufacturer, to ensure minimal arc tracking across the insulator surface.

10. Pantographs drawing current while traversing the section insulator shall not cause excessive arcing or damage to the section insulator or pantograph.

11. The design shall allow for torsional forces resulting from the passage of multiple pantographs combined with lateral wind loads at service speed.

12. Contact wire runner skids shall provide a smooth transition from one section to another.

13. Design factors of safety shall be consistent with those used in the design of the catenary system, and as specified by CPUC G.O. 95.

14. The design shall comply with the following electrical requirements:

    a. Nominal Voltage: 800 V (DC).

    b. Nominal Voltage Range: 525 V (DC) to 900 V (DC).

    c. Maximum Voltage Under Regeneration: 1000 V (DC).

15. The design shall satisfy the environmental conditions normally expected in an outdoor installation.

16. The design shall provide full performance within a conductor temperature range of 25°F to 130°F.

2.02 COMPONENTS

A. Typical components to be provided are as follows:

1. Arcing Horns and Arc Traps: Skids shall be designed with each end upturned to form arcing horns. A flashover shall take place across the body unit and not across the insulation.

2. Arc Traps: The tips of the arc traps shall be replaceable.

3. Telescopic Anti-Torsion Guide Tubes if used: The inner tube of the anti-torsion guide tubes shall be free to move vertically to lessen the impact of the pantograph.

4. Hardware: Hardware shall consist of the manufacturer's recommended items and shall include, but shall not be limited to, bolts, U-bolts, washers, clamps (including contact wire clamps), turnbuckles, support connectors, braces, insulators and insulating beams.

2.03 PROTECTIVE FINISH

A. Section insulator components shall have an approved protective finish or shall be inherently self-protecting. Ferrous metal components shall be galvanized as specified in Section 34 23 39, “OCS Assemblies, Fittings and Hardware.”

PART 3 – EXECUTION

3.01 INSTALLATION REQUIREMENTS

A. Section insulator assembly installation is covered in Section 34 23 53, "Overhead Contact System Installation," of these technical specifications.

3.02 FIELD QUALITY CONTROL

A. Field tests shall be carried out as recommended by the manufacturer.

B. Field tests shall be witnessed by VTA. Certified copies of the test results shall be submitted as required by Article 1.03C herein.

END OF SECTION 34 23 46

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SECTION 34 23 49

INSULATORS

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for furnishing and testing of suspension, strain, and stand-off insulators for the Overhead Contact System (OCS), as shown on VTA LRT Standard Detail Manual, the Plans, and specified herein.

B. Contractor shall submit details of all insulators for each of the required assemblies, based on the performance requirements, working loads, and basic dimensions shown on VTA LRT Standard Detail Manual, or the Plans and specified herein. The proposed insulators shall be subject to acceptance and approval by VTA.

C. The OCS insulators shall comply with the General Orders of the State of California Public Utilities Commission (CPUC), particularly the requirement for double insulation. All insulators shall clear the pantograph dynamic envelope.

D. Unless otherwise specified on VTA LRT Standard Detail Manual or the Plans, synthetic insulators must be used. Porcelain insulators shall be acceptable only if so indicated on VTA LRT Standard Detail Manual and the Plans and/or accepted by VTA. An equivalent porcelain insulator may be used as an alternate to a synthetic insulator, subject to acceptance by VTA.

E. Insulator installation is specified in Section 34 23 53, "Overhead Contact System Installation," of these technical specifications.

1.02 REFERENCED STANDARDS

A. American National Standards Institute (ANSI):

1. C29.1 Test Methods for Electrical Power Insulators.
2. Z55.1 Gray Finishes for Industrial Apparatus and Equipment (Discontinued).

B. American Society for Testing and Materials (ASTM):

1. A47/A47M Standard Specification for Ferritic Malleable Iron Castings.
2. A153/A153M Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
3. C150 Standard Specification for Portland Cement.
4. C151 Standard Test Method for Autoclave Expansion of Portland Cement.
5. D116 Standard Test Methods for Vitrified Ceramic Materials for Electrical Applications.

1.03 SUBMITTALS

A. Manufacturer's drawings, catalog cuts, test reports and certification shall be provided showing compliance with the applicable requirements of the referenced Standards, these technical specifications and VTA LRT Standard Detail Manual and the Plans as to materials, mechanical and electrical strength, design, manufacturing and testing of the insulators.

B. Samples as requested by VTA.

1.04 QUALITY CONTROL

A. Contractor shall perform the following:

1. Material qualification testing and certification for acceptance of materials, components and assemblies.

2. Job control testing of in-progress work being performed in shops, factories and on-site.

3. On-site inspection of specified work elements.

B. Federal, State and Local Authorities: Conform to applicable codes and regulations.

C. Materials and components manufactured to applicable foreign standards, including metric standards, are acceptable, provided that Contractor submits written evidence, in the English language, that they are equal or superior to those complying with the standards listed in Article 1.02, "Reference Standards," and written approval is obtained from VTA.

D. Quality Assurance shall be in accordance with the provisions of Special Conditions, Section 6.26 “Quality Assurance and Quality Control Requirements.”

1.05 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 – PRODUCTS

2.01 PORCELAIN INSULATORS

A. The insulators shall be made of the best commercial-grade wet-process porcelain, in accordance with ASTM D116.

B. The entire porcelain surface of the insulators that will be exposed after assembly shall be glazed in No. 70 light gray color as specified in ANSI Z55.1.

C. The surface shall be free of imperfections. Pieces with imperfections in the glaze repaired by re-coating and re-finishing, as well as those pieces repaired by re-touching with paint, will be rejected.

2.02 SYNTHETIC INSULATORS

A. General: Synthetic insulators may be fabricated from any of the following materials, or combinations thereof, depending on type or application:

1. Molded ethylene propylene copolymer with hydrated alumina filler.

2. Fiberglass-reinforced epoxy solid rod.

3. Composite type, with molded ethylene propylene copolymer jackets or skirts formed over a fiberglass-reinforced epoxy core.

4. Insulators shall be furnished complete with integral galvanized or stainless steel hardware for connection to supports or catenary hardware. Synthetic insulators shall be products of Ohio Brass, ABB (ASEA-Brown Boveri), Siemens, or VTA-approved equal.

B. Types and Applications: Specific types and applications of synthetic insulators for use with cantilevers, cross-spans and tunnel or structure ceilings, or for use as strain insulators, shall be as shown on VTA LRT Standard Detail Manual and the Plans.

2.03 METAL PARTS

A. The metal parts of the insulators shall be made of malleable iron, ASTM A47/A47M Grade 35018, or of open-hearth or electric furnace steel. All ferrous metal parts shall be galvanized in accordance with ASTM A153/A153M. Insulator fittings shall provide for connections as shown.

2.04 CEMENTING

A. Cement used for assembling porcelain to metal shall meet or exceed the requirements of ASTM C150 and ASTM C151.

B. Cement for synthetic insulators shall be of the types recommended by the insulator manufacturer for use with his materials.

2.05 PAINTING

A. To protect the galvanizing from harmful chemical action of the cement, the hardware which is in contact with cement shall be coated with a bituminous paint, or shall be as recommended by the insulator manufacturer for use with his materials.

2.06 PERFORMANCE AND TESTING

A. Insulators shall be tested in accordance with ANSI C29.1.

B. The mechanical strength of suspension and strain insulators shall meet or exceed the strength indicated on VTA LRT Standard Detail Manual and the Plans. Where the strength is not indicated, insulators shall exceed the ultimate strength of the conductor or guy to which it is attached.

C. Insulators for various uses shall have ratings not lower than the classes indicated on VTA LRT Standard Detail Manual and the Plans.

D. The manufacturer shall provide a certificate of compliance with the applicable portions of the referenced ANSI Standards, these technical specifications, and VTA LRT Standard Detail Manual and the Plans.

E. Types and suggested electrical values and minimum mechanical characteristics for OCS insulators are shown on VTA LRT Standard Detail Manual and the Plans.

2.07 MARKING

A. Each insulator shall bear the manufacturer's name or trademark and year of manufacture, clearly and permanently imprinted, without affecting the appearance or the function of the item.

2.08 ELECTRICAL RATINGS

A. All insulators shall have the following ratings, unless otherwise noted:

1.	Nominal Full-load System Voltage	800 V (DC).
2.	Insulation Level	3.7 kV (AC), rms.
3.	Creepage Distance	1 5/8” min.
4.	60 Hz Withstand Voltage, Dry	25 kV.
5.	60 Hz Withstand Voltage, Wet	12 kV.

B. Synthetic spool insulators shall withstand a 25 kV flashover across 2 1/2” leakage distance.

PART 3 – EXECUTION

3.01 INSTALLATION REQUIREMENTS

A. Insulator installation is covered in Section 34 23 53, "Overhead Contact System Installation," of these technical specifications.

END OF SECTION 34 23 49

SECTION 34 23 53

OVERHEAD CONTACT SYSTEM INSTALLATION

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for installation of the complete Overhead Contact System (OCS) associated with this project.

B. Work under this Section includes furnishing and installing of OCS, Simple Catenary Auto-Tension (SCAT), in accordance with these Technical Specifications and Contract Drawings.

C. Equipment to be installed includes TES metal poles, down guy anchor assemblies, pole and guy anchor foundations (CIDH), cantilever arm assemblies, pole bands and brackets, headspans, contact and messenger wires, termination assemblies, surge arresters, pole mounted disconnect switches, insulators, section insulators, airbreak assembly, midpoint anchors, feeders, jumper wires and cables, grounding, TES pole numbering, and other components specified in the Contract Documents required to provide a complete operating OCS.

D. Related Sections:

1. 26 41 23.16 – DC Surge Arresters

2. All 34 23 ## Sections of these Technical Specifications

E. General Requirements:

1. All catenary components shall be interchangeable, like for like, and shall be made such that they can be easily removed during maintenance operations.

2. All OCS installations shall be configured to clear the vehicle and pantograph dynamic envelope.

3. The as-built OCS installation shall meet the requirements specified herein and specified elsewhere on the Contract Documents.

1.02 REFERENCED STANDARDS

A. Santa Clara Valley Transportation Authority LRT Standard Detail Manual:

1. Section 10 – Traction Electrification

B. State of California Public Utilities Commission (CPUC):

1. G.O. 95 — Rules for Overhead Electric Line Construction.

1.03 SUBMITTALS

A. Test Reports: 6 certified copies of reports of all field tests shall be submitted to VTA as required or recommended by these technical specifications and referenced standards, or as necessary to establish compliance with the Contract Documents.

B. Contractor shall submit proposed stringing and restraining methods, as specified in this Section, Article 3.10, “Messenger and Contact Wire Stringing” and Article 3.11, “Parallel Feeder Cable Stinging.” Include proposed splice locations, if any.

C. Contractor shall submit prestressing methodology and values for messenger wire, contact wire, and parallel feeder cable for VTA approval 120 days from NTP.

D. Acceptance measurements shall be submitted on completion of installation of individual OCS tension section segments, before final acceptance testing.

E. Conductor stringing records shall be prepared for each catenary tension section and submitted on completion of the work. These records shall show, as a minimum:

1. Wire run number.

2. Structure location (Pole number and Station) at anchorages.

3. Reel number of messenger wire.

4. Reel number of contact wire.

5. Length of each conductor installed.

6. Weather description and ambient temperature at start and end of stringing.

7. Location of factory splices.

F. Cable Pull: 6 copies of cable pull calculations shall be submitted for approval before cable installation.

G. Torque Requirements: Contractor shall submit manufacturer recommended torque requirements for all OCS hardware.

H. Staging Plans: Contractor shall submit proposed staging Plans for work at interface with existing system.

I. Field Details and Changes: Contractor shall submit records of field details and changes in regard to installation of headspan assembly.

J. Product Data: Submit other items supplied by Contractor and not specified in Section 34 23 26, “OCS Assemblies, Components and Fittings,” and Section 34 23 69, “Overhead Contact System Testing and Commissioning,” within a time frame to be specified by VTA.

K. Personnel Qualifications: Submit qualifications, based on requirements stated in Article 1.05 herein, and proof of experience for OCS Installation Supervisor and OCS Installation Crew Foremen for approval by Resident Engineer prior to mobilization of installation personnel.

L. On completion of construction, Contractor shall revise and submit a full set of OCS Layout Drawings and structure cross section drawings, to show as built dimensions and details as part of the Project Record Documents in accordance with Section 01 78 39, "Project Record Documents."

1.04 QUALITY ASSURANCE

A. Standards applicable to products covered in this Section have been listed in other sections of these technical specifications, and apply here.

B. All OCS installations shall comply with the requirements of CPUC G.O. 95.

C. Quality Assurance shall be in accordance with the provisions of Special Conditions, Section 6.26 "Quality Assurance and Quality Control Requirements."

1.05 OCS INSTALLATION PERSONNEL QUALIFICATIONS

A. Supervisor:

1. An OCS Installation Supervisor shall be appointed to supervise the complete OCS installation, field testing, and commissioning of the OCS equipment provided under this Contract.

2. The OCS Installation Supervisor shall have a minimum of 10 years of experience as a superintendent or general foreman in charge of OCS installations.

B. Crew Forman: A foreman shall be appointed for each crew not exceeding six OCS installers or where crews work independently. The foreman shall have at least 10 years of experience in the installation of OCS and demonstrated experience as foreman of OCS installations or similar overhead line work.

C. OCS Installer: OCS installers shall be qualified by experience and training to perform the specified work, and shall be outside linesmen who are employees of a California licensed electrical Contractor. A Journeyman Lineman shall have completed a State of California or federally approved Outside Line Construction and Maintenance apprenticeship program of 6000 hours of on-the-job training.

1.06 MEASUREMENT AND PAYMENT

A. Pole and Guy Anchor Foundations (CIDH): See Section 34 23 15 for Measurement and Payment.

B. OCS Metal Poles: See Section 34 23 13 for Measurement and Payment.

C. Down Guy Anchor Assembly: The contract price paid per unit price (EA) for Down Guy Anchor Assembly shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Down Guy Anchor Assembly complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

D. Grounding Assembly: The contract price paid per unit price (EA) for Grounding Assembly shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Grounding Assembly complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

E. Counterweight Assembly – SCAT: The contract price paid per unit price (EA) for Counterweight Assembly shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Counterweight Assembly complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

F. Fixed Termination Assembly – SCAT: The contract price paid per unit price (EA) for Fixed Termination Assembly shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Fixed Termination Assembly complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

G. Parallel Feeder Cable Termination Assembly: The contract price paid per unit price (EA) for Parallel Feeder Cable Termination Assembly shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Parallel Feeder Cable Termination Assembly complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA

H. Pole Brackets: The contract price paid per unit price (EA) for Pole Brackets shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Pole Brackets complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA

I. Pole Bands: The contract price paid per unit price (EA) for Pole Bands shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Pole Bands complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

J. Cantilever Arm Assemblies: The contract price paid per unit price (EA) for Cantilever Arm Assembly shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Cantilever Arm Assembly complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

K. Twin Track Cantilever Arm Assembly: The contract price paid per unit price (EA) for Twin Track Cantilever Arm Assembly shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Twin Track Cantilever Arm Assembly complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

L. Parallel Feeder Support Assembly: The contract price paid per unit price (EA) for Parallel Feeder Support Assembly shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Parallel Feeder Support Assembly complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

M. Headspan Assembly (4 track): The contract price paid per unit price (EA) for Headspan Assembly shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Headspan Assembly complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

N. Head Guy Assembly: The contract price paid per unit price (EA) for Head Guy Assembly shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Head Guy Assembly complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA

O. OCS Bare Conductors – SCAT: See Section 34 23 23 for Measurement and Payment.

P. OCS Jumper Assemblies: See Section 34 23 23 for Measurement and Payment.

Q. Feed Point and By-Pass Assemblies: The contract price paid per unit price (EA) for the Feed Point and By-Pass assemblies shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Feed Point and By-Pass assemblies complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

R. Parallel Feeder Cable Continuity Jumper: The lump sum payment (LS) for Parallel Feeder Cable Continuity Jumper shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Parallel Feeder Cable Continuity Jumper complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

S. DC Surge Arrester: See Section 26 41 23.16 for Measurement and Payment.

T. Section Insulator: See Section 34 23 46 for Measurement and Payment.

U. In-Span Insulator: The contract price paid per unit price (EA) for In-Span Insulator Assemblies shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing In-Span Insulator Assemblies complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

V. Disconnect Switches: See Section 34 23 19 for Measurement and Payment.

W. Airbreak Assembly: The contract price paid per unit price (EA) for Airbreak Assembly shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Airbreak Assembly complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

X. Midpoint Anchor Assembly: The contract price paid per unit price (EA) for Midpoint Anchor Assembly shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Midpoint Anchor Assembly complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

Y. Hanger Assembly: The contract price paid per unit price (EA) for Hanger Assembly shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Hanger Assembly complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

1. Hanger Assembly (Typical)
2. Hanger Assembly (Airbreak)

Z. Knuckle Assembly: The contract price paid per unit price (EA) for Knucle Assembly shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Knuckle Assembly complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

AA. TES Pole Numbering: The contract price paid per unit price (EA) for TES Pole Numbering shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing TES Pole Numbering complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

BB. Interface Work with Existing System (Alum Rock): The lump sum payment (LS) for Interface Work with Existing System (Alum Rock) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing the Interface Work with Existing System (Alum Rock) complete in place, as shown on the staging drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

(Not Used)

PART 3 – EXECUTION

3.01 GENERAL REQUIREMENTS

A. Reference points for location of OCS structures and facilities are as shown on the Plans.

B. Actual location of OCS structures and underground facilities shall be checked by Contractor, including foundations, underground ducts, handholes, pull boxes and manholes that are used for the underground feeder cables outside of the TPSS.

C. Before installing pole, Contractor shall check the pole foundation and down guy anchor locations, and advise VTA of any deficiencies that could result in an unacceptable OCS installation if not corrected. VTA will advise Contractor of remedial action to be taken.

D. Before any on-site installation work is started in a given area, VTA will confirm that the tracks are in their final position. If adjustment of track alignment or level is still in progress, VTA at their discretion may instruct that installation proceed on the basis of design drawings. Any adjustments needed before acceptance will be paid for by change order.

E. Subject to Article 3.01.D, Contractor shall measure and record the actual location of each OCS foundation with respect to the adjacent tracks, and the track super-elevation magnitude and direction, before fabrication and installation of poles, cantilevers and other OCS structures and assemblies, to insure that, in all locations, these structures are installed with the correct geometrical relationship to the track alignment as shown on the Plans.

F. The reference point for locating structures with respect to the track shall be the design position, as shown on the Plans. Any deviations in the actual position of the track from the design position shown on the Plans shall be referred to VTA.

G. The setting dimensions for each structure with respect to the reference point are as given in the OCS Layout Schedule. Structure offsets shall generally be at right angles to the track centerline.

H. All major structures that might interfere with OCS installation shall be clearly identified in terms of location and elevation, referenced to the adjacent track.

3.02 INSTALLATION TOLERANCES

A. The installed OCS shall conform to the dimensional requirements shown on the Contract Drawings within the following tolerances:

Standard pole bowing effect	2percent maximum
Counterweight pole bowing effect	1 percent maximum
Pole base elevation	1 inch
Pole rake (after loading)	1 inch (at top)
Cantilever along track offset	+3 inches
Steady arm heel setting	- 0 inch, + 1 inch
Contact wire height in open route	1 inch
Contact wire height in stations	1/2 inch
Contact wire stagger at registration	1/2 inch
System height	1 inch
Hanger length	+/-1/4 inch
Hanger location	+/-3 inches
Messenger and contact wire lateral location at support	1 inch
Wire tension	50 pounds

3.03 OCS POLES

A. Poles shall be installed as shown on the Plans and specified in Section 34 23 13, "Overhead Contact System Metal Poles."

B. The type, location, setting height, offset and rake of each pole shall be as specified in the OCS Layout Schedule.

3.04 DOWN GUYS

A. Down guys of the sizes and types shown shall be installed as indicated on the Plans.

B. Down guys shall be installed before the catenary wires are strung. They shall be pulled taut and secured in place with provisions for future adjustment as required to hold the structure in proper alignment after wires are tensioned.

C. Down guy attachments to the TES poles and down guy anchor foundations shall be installed as shown on the Plans.

D. Each guy to an anchor shall have an 8-foot guy guard, installed as shown on the Plans unless otherwise directed by VTA.

E. Guy strands shall not be spliced.

3.05 BRACKET ARMS, CANTILEVER ASSEMBLIES, AND OCS SUPPORTS

A. The type and standard design of bracket arm, cantilever or OCS support to be installed on each pole, support bracket, or pole band is referenced on the OCS Layout Schedule and the Plans. Only approved assemblies and components are to be used, in accordance with Section 34 23 39, "OCS Assemblies, Fittings and Hardware."

B. Bracket arms, cantilevers and OCS supports shall be assembled and installed to meet all dimensional criteria and to clear the pantograph dynamic envelope.

C. The wire heights and stagger given on the Plans are related to the high rail elevation and projected centerline of track respectively.

D. For stability during stringing, the bracket arms or cantilevers shall be temporarily restrained to prevent collapse due to stringing. The details of the restraint shall be submitted to VTA for acceptance.

E. On auto-tensioned sections, the along-track offset of OCS support or cantilever on completion, shall be in accordance with its distance from the midpoint anchor or fixed anchor for the prevailing temperature.

F. Cotter pins and nuts on each support or cantilever shall be located on the same side of the structure, to assure uniformity along the line.

G. Assemblies fitted with pins, cotters, bolts and nuts shall be oriented where possible in such manner as to lock these components together by gravity if the pins or nuts should become detached under service conditions.

H. Components employing a hinge or swivel shall be greased before assembly of the rubbing surfaces, and cleaned of extra grease.

I. Defects in the galvanizing of the completed assemblies shall be repaired by the application of a suitable zinc-rich, cold-galvanizing repair paint, ZRC Cold Galvanizing Compound or VTA-approved equal, or the parts shall be replaced, as determined by VTA.

J. After installation of OCS supports or cantilevers, stringing and final tensioning of conductors, final adjustments to the stagger, steady arm heel setting, contact wire, messenger wire heights, and support and registration assemblies shall meet specified installation tolerances.

K. Conductor interfaces of all clamps for feeder terminations, equalizing jumpers and continuity jumpers shall be coated with conductive grease and cleaned of extra grease.

L. Conductive lubricating grease shall be applied to the retainer bars of cross contact bridges, and cleaned of extra grease.

M. The cross-track alignment of the vertical centerlines between messenger, contact or bridle wires shall be within 1:24 of vertical separation.

N. An approved conductive lubricating grease shall be applied to swivels, hinges and similar items.

3.06 HEADSPANS

A. Headspans assemblies shall be manufactured in accordance with the approved OCS Layout Schedule of the Contract Drawings and cross-sections.

B. Assemble headspans after the location has been surveyed and the following necessary information and dimensions measured along the axis of the span have been checked:

1. Centerline of track to face of poles.

2. Design track separations.

3. Elevation of the foundations in relationship to the tracks.

4. Track superelevations and direction.

C. Contractor shall review and note all field changes from the design and submit these changes to VTA for its recommendations.

D. Minor field adjustments of hangers, contact and/or messenger heights shall be performed by Contractor as directed by VTA at no additional cost.

E. Provide headspan insulation in addition to inter-track insulation that may be required.

F. Stagger, wire height and heel settings shall be in accordance with the Plans or as directed by VTA.

G. Tensions and attachment heights for headspans shall be as shown on the Plans. Should further adjustment be necessary to obtain the required CW heights, the attachment heights may be adjusted provided the maximum working load of the assembly, components, or pole supports is not exceeded.

3.07 HARDWARE

A. All hardware shall be installed in accordance with the manufacturer’s instructions and accepted shop drawings, where applicable. Bolts and nuts shall be properly tightened in accordance with the manufacturer’s recommendations. All bolts shall be of sufficient length for a full thread beyond the nut and locknuts, but shall not protrude beyond the nut and locknut to exceed 1/2”, excluding foundation bolts. Bolt ends shall not be cut off. Where locknuts are not used, lock washers shall be provided. Shop drawings must show critical fit items to ensure dimensions are correct when materials are assembled.

B. All locknuts shall be installed according to manufacturer’s recommendations.

C. Hardware shall be installed using tools and methods specified by the manufacturer and approved by VTA.

D. Hardware shall be inspected for cleanliness and damage, any defective hardware will be rejected. Defective fittings shall not be used:

1. Hardware that do not fit.

2. Cracked hardware.

3. Hardware with galvanizing damage during installation.

4. Hardware found to be defective in any other way.

E. Fittings shall not use epoxy inserts as a method of attachment.

3.08 INSULATORS

A. Contractor shall provide double insulation in accordance with CPUC G.O. 95.

B. All insulators shall be clean before installation. Only clean rags, free from any abrasive material shall be used for cleaning insulators. Wire brushes shall not be used for cleaning any parts, metal or otherwise. In the completed line, all insulator assemblies and hardware shall be clean, bright and free from nicks, chips or other marks. All torsion on messenger wire shall be released prior to installing cut-in insulators.

C. After installation of the OCS support system, but before the Hi-pot tests stated in Section 34 23 69, “OCS and TES Interface Testing and Commissioning,” all insulators shall be megger tested. Insulators that are found to be defective shall be replaced.

D. Insulators with slight damage shall be repaired as recommended by the manufacturer. If the damage is appraised by VTA as excessive, the insulator shall be replaced. Cracked insulators shall be replaced.

E. Porcelain insulators shall be used only where shown on VTA LRT Standard Detail Manual and the Plans. An equivalent porcelain insulator may be used as an alternate to a synthetic insulator subject to acceptance by VTA.

F. Porcelain guy strain insulators and other types of porcelain insulators shall not be used for headspans where they are exposed to vandals and their appearance might be objectionable.

3.09 TERMINATION ASSEMBLIES

A. Termination assemblies shall be installed at locations indicated on the Plans.

B. The type of termination assembly at each location shall be as indicated on the Plans.

C. Counterweight assemblies shall be free-moving between conductor temperatures of 20F and 130F.

D. Special care shall be taken during installation of counterweight assemblies to obtain the correct setting position for the wire temperature and travel clearance for the balance weight and pulley assemblies. Preliminary tensioning of the OCS to remove creep shall be completed before finalization of the counterweight settings.

E. Balance weights for counterweight tensioning shall be lead/cast iron, as shown on VTA LRT Standard Details, to make up the counterweight cake required to maintain the required tension in the conductors.

F. An approved lubricating grease shall be applied to pulley bearings, swivels, guideways, guide rods and wire ropes as directed by VTA.

G. Contractor to develop a spreadsheet for the installation of counterweight assembly. The spreadsheet shall include the following as-built information, but not limited to:

1. Temperature during installation in degrees F.
2. Number of counterweight cakes.

3. Final weight of counterweight assembly (counterweight cakes and support rod).

4. Distance from single pully to centerline of pole.

5. Distance from bottom of counterweight support rod to top of pole baseplate.

3.10 MESSENGER AND CONTACT WIRE STRINGING

A. All conductors shall be installed in accordance with good overhead line practice, subject to acceptance of VTA, and the manufacturers' recommendations. Due regard shall be made for conductor creep. The initial stretch and the ten-year creep shall be removed at the time of installation. The pre-tensioning method to be used shall be as per conductor manufacturer's recommendations and shall be approved by VTA for the applicable conductor, and shall include:

1. The pre-tensioning tension for the conductor before being reduced to normal tension.

2. The duration and number of cycles the conductor shall remain at the pre-stressed tension.

3. Contractor's check of the adequacy of the catenary structures to ensure that they can safely carry any proposed loading in excess of the design values.

B. Conductor reels that are damaged or will prejudice stringing operations shall not be used. Sufficient tension must be maintained in the conductors during stringing to ensure that the conductors are never dragged along the ground or track between support points.

C. Conductor tensions, cantilever and OCS support and registration settings, and counterweight settings are temperature related. Final tensions are accomplished by adjustments made on counterweights.

D. Conductor Erection Spreadsheet:

1. Develop a Conductor Erection Spreadsheet using Temperature/Tension Charts in Contract Drawings.

2. Prior to setting conductor tension, measure actual conductor temperature using contact thermometer.

3. Enter conductor temperature and span data on the Conductor Erection Spreadsheet and use to ensure conformity to actual wire data before starting contact wire final stringing.

4. Update Conductor Erection Spreadsheet for each section of wire.

E. It shall be Contractor's responsibility to ensure that the installation complies with the acceptance requirements for the Overhead Contact System as specified in Section 34 23 69, "OCS and TES Interface Testing and Commissioning."

F. Kinks in the wires and de-stranding (birdcaging) of stranded conductors shall be prevented. Damage of this nature will be cause for rejection.

G. The contact wire shall be free of twists from anchor clamp to anchor clamp.

H. In-running contact wire crossed by another in-running contact wire shall be fitted with a contact bridge on auto-tensioned and fixed-terminated sections.

I. Equalizing and overlap jumpers and feeder assemblies shall be installed as shown on Plans, and in accordance with the manufacturer's recommendations. Jumpers shall be shaped and supported to reduce possible fatigue failure caused by uplift and shall be of a length to provide for the differential movement of different catenary systems at overlaps, without strain. The jumpers shall be formed to ensure that they will maintain adequate clearance to the dynamic pantograph under all conditions of operation.

J. All termination fittings shall be oriented in accordance with the manufacturer's recommendations.

K. Both contact and messenger wires shall be grounded during and after the stringing process and shall be removed before energization.

L. After final tensioning has been completed, the headspans and cantilevers shall be checked and the conductor heights, staggers, heel settings and along track position adjusted as required in order to obtain the values given in Contract Layout Drawings.

3.11 PARALLEL FEEDER CABLE STRINGING

A. Parallel feeder cables shall be installed in accordance with good overhead line practice, subject to acceptance of VTA, and the manufacturer's recommendations. Due regard shall be made for the conductor creep. The initial stretch and the ten-year shall be removed at the time of installation. The pre-tensioning method to be used shall be as per conductor manufacturer's recommendations and shall be approved by VTA, and shall include:

1. The pre-tensioning tension for the conductor before being reduced to normal tension.
2. The duration and number of cycles the conductor shall remain at the pre-stressed tension.
3. Contractor's check of the adequacy of the catenary structures to ensure that they can safely carry any proposed loading in access of the design values.

B. Conductor reels that are damaged or will prejudice stringing operations shall not be used. Sufficient tension must be maintained in the conductor during stringing to ensure that the conductor is never dragged along the ground or track between supports.

C. Conductor Erection Spreadsheet:

1. Develop a Conductor Erection Spreadsheet using Temperature/Tension Charts in the Contract Drawings.
2. Pior to setting the conductor tension, measure actual conductor temperature using contact thermometer.
3. Enter conductor temperature and span date on the Conductor Erection Spreadsheet and use to ensure conformity to actual wire data before starting conductor final stringing.
4. Update Conductor Erection Spreadsheet for each section of wire.

D. It shall be the Contractor's responsibility to ensure that the installation complies with the acceptance requirements for the Overhead Contact System as specified in Section 34 23 69, "OCS and TES Interface Testing and Commissioning."

E. Kinks in the cable and de-stranding (birdcaging) shall be prevented. Damage of the nature will be cause for rejection.

F. Parallel feeder equalizing taps shall be installed as shown on Plans, and in accordance with the manufacturer's recommendations. Feeder tap cables shall be of a length to provide for the differential movement of different catenary systems without strain. Parallel feeder equalizing taps shall be installed at a maximum distance of 500 feet between consecutive equalizing taps.

G. All termination fittings shall be oriented in accordance with the manufacturer's recommendations.

H. Parallel feeder cables shall be grounded during and after the stringing process and shall be removed before energization.

3.12 CONDUCTOR SPLICES

A. Conductor splicing may be necessary and is permitted where existing conductors need to be modified and terminated to new locations subject to site-specific approval by VTA.

B. No other contact and messenger wire splices are permitted without prior approval of VTA.

3.13 HANGERS

A. Hanger span sets and locations shall be as indicated on the OCS Layout Schedule.

B. Hanger lengths for spans containing in-span hardware and assemblies shall be checked and calculated by Contractor before their fabrication, using actual weights of all approved in-span hardware and components.

C. Hanger size and spacing shall be as shown on the Plans.

D. Hangers shall be installed uniformly along the line, with the tail of each crimp connector facing the same rail when looking in the direction of increasing station. Hanger identification and temporary tie wires shall be removed from the completed installation.

E. Hangers shall be plumb within +/- 1/2".

3.14 INSULATED AND UNINSULATED OVERLAPS, AIR BREAKS AND CROSSOVERS

A. The arrangement for tangent and curved track SCAT system overlaps, air breaks and crossovers shall be installed as shown on the Plans.

B. The location, specific dimensions for wire heights and staggers, and the support and registration assembly types are shown on the OCS Layout Schedule and detailed on VTA LRT Standard Detail Manual and Plans.

C. Final adjustments shall be made, as required, to provide acceptable transfer of the pantograph from one tension length to the other without loss of contact.

3.15 CONTACT BRIDGES

A. Contact bridges shall use straightened contact wire or solid copper rod and shall be installed at turnout locations shown on Contract Layout Drawings.

B. The contact bridges shall allow free movement of the contact wires over the operating temperature range.

C. The upper contact wire shall be adjusted to float through the contact bridge assembly under normal conditions with no pantograph uplift.

3.16 SECTION INSULATORS

A. Section insulator types and locations shall be as shown on the Plans.

B. Section insulators shall be installed and supported as recommended by the manufacturer and as required to meet the design requirements specified in Section 34 23 46 "Section Insulators," of these technical specifications.

C. Contractor shall obtain and use the assistance of a manufacturer's representative in supervising the installation of the section insulators.

D. After installation, adjustment may be required to insure proper operation. This shall be done as required and as directed by VTA.

3.17 MIDPOINT ANCHORS

A. Midpoint anchor assemblies and contact wire restraint assemblies shall be installed at the locations indicated on the Plans.

B. Midpoint guy strand termination assemblies shall be installed as shown on the Plans.

3.18 GALVANIZED STEEL AND STAINLESS-STEEL WIRE AND WIRE ROPE

A. Galvanized steel and stainless-steel wire and wire rope shall be cut and installed using tools and methods specified by the manufacturer. Sufficient length shall be left at the terminations for minor adjustments, as determined by VTA.

B. Splicing of the galvanized steel and stainless steel wire and wire rope will not be permitted. This includes all applications shown on the Plans.

3.19 DISCONNECT SWITCHES

A. Refer to Section 34 23 19, “OCS Pole Mounted Disconnect Switch.”

3.20 FEEDER CABLES

A. Contractor shall furnish the feeder cable and other hardware to complete the installation. Cable pull procedures and calculations shall be submitted for approval before installation.

B. Insulated cables shall be installed by Contractor in underground ducts, handholes and manholes , and in above-ground feeder risers and conduit provided under this Contract, in designated areas shown on the Plans.

C. Water seals shall be provided at feeder cable riser conduits of the OCS poles.

D. A lubricating compound shall be used while pulling cables. Cable pulling tension applied during the pulling process shall not exceed the manufacturer's written recommendations. Rollers, jam and quadrant blocks shall be used as required to facilitate cable installation.

E. Cable pull lengths shall be maximized so as to minimize splices. Splices shall be allowed only in manholes. Splices shall be made as specified in Section 34 21 28, "Traction Power Wire and Cable."

F. Cables in the manholes shall be supported by galvanized steel hangers, racks and chairs, spaced a maximum of 3 feet apart. Splices, where required, shall be supported on both sides of the joint. Feeder riser taps along parallel feeders shall be installed as shown on the Plans. All racks and accessories in the power pullboxes, and all cable and splice supports, shall be furnished and installed by Contractor.

G. Where required, cables shall be suspended from cross-span wires and bracket arms or cantilevers as shown on the Plans.

H. Terminations: Terminations at sectionalizing switches, to the overhead contact system, the grounding grid system, and the substation DC switchgear and negative bus, shall be made by Contractor. Each cable end shall be cleaned with an appropriate decontaminant immediately before making the connection. Terminations shall comprise all DC positive cables at the switchgear, disconnect switches, OCS, DC negative return cables at the negative bus, and control wiring between the traction power substations and externally mounted equipment. Terminations shall be made as specified in 34 21 28, "Traction Power Wire and Cable," using the appropriate termination kits to be supplied by Contractor.

I. Inspection and Tests: An insulation test shall be performed by Contractor, and the results recorded and submitted to VTA, as specified in Section 34 23 69, "OCS and TES Interface Testing and Commissioning."

3.21 JUMPER CABLES

A. Configurations of all types of jumpers shall be approved by VTA.

B. Jumper wires shall have cut and tied ends projecting not more than 1/2" through open clamps. The cut ends of the jumper wires in contact wire clamps shall face to the direction of the train travel and shall be dressed with wire wrapping to prevent fraying for which tie wraps are unacceptable.

C. Continuity jumpers shall be of a length and configuration appropriate to the anticipated differential movement of the conductors. Contractor shall determine the lengths of jumpers, based on actual field measurements.

D. In all cases, jumpers shall be installed and trained so as to avoid conflicts with the pantographs, adjacent cantilevers, and hangers.

E. Each cable end shall be cleaned with an accepted decontaminant immediately before making connections.

F. Connectors shall be as indicated on the Plans and shall be installed in accordance with the manufacturer's recommendations.

G. Bolts in bolt-type connectors shall be torqued to the bolt manufacturer's recommendations, using a calibrated torque wrench.

3.22 SURGE ARRESTERS

A. Surge arrester assemblies shall be in accordance with Section 34 23 26, "OCS Assemblies, Components, and Fittings," in conjunction with these Specifications.

B. Surge arrester shall be connected to the upper terminal of the DC disconnect switch with a #4 AWG flex insulated copper cable, as specified and as shown on the Plans, or with increased conductor and insulation ratings if so recommended by the surge arrester manufacturer.

C. Each surge arrester shall be suitable for OCS pole mounting, and supplied with all accessories required for mounting. The surge arrester assembly shall incorporate an individual grounding system which shall be connected to a ground rod or ground mat as shown in the Contract Drawings.

D. Each grounding connection shall have a resistance of 5 Ohms, or less or as specified by the surge arrester manufacturer for the type of unit supplied, if the recommended resistance is less than 5 Ohms.

E. Each grounding connection shall be tested individually in accordance with the appropriate procedures specified in Section 34 23 69, "OCS and TES Interface Testing and Commissioning."

F. Bonding cable connections between the surge arresters, OCS, and the DC disconnect switches, and between the surge arresters and the grounding system, shall be installed with a minimum number of bends and the shortest possible length. Bends in the cables shall be no less than 8-inch radius.

G. Surge arrester ground cable shall be uninterrupted between arrester and ground. No splices or other connections shall be permitted.

H. Bonding connections between the surge arresters and the grounding systems shall be of the exothermic weld type.

I. Refer to Section 26 05 26, "Grounding and Bonding for Electrical Systems," for general requirements on grounding and bonding connections.

3.23 CONDUITS

A. Contractor shall furnish and install underground conduits within each substation site and above ground conduits as shown on the Plans.

B. Contractor shall provide all materials, hardware, and labor needed to interface the underground ductbanks within the TPSS site with the CSD, resulting in a complete installation.

C. Conduit and fittings shall be provided to ensure mechanical support of the cable as well as a watertight seal at feeder spouts of the OCS poles. The method of cable support shall be submitted to VTA for approval.

D. Conduits by the track for negative feeders shall be furnished with watertight plug and seal after the installation of the power cables.

E. The galvanized rigid steel conduit along the side of a TES pole with DC disconnect switch equipped with dropping resistor assembly shall be bonded to the outside of the pole and shall be equipped with a weather head on top.

F. Below ground galvanized rigid steel conduits shall be PVC coated.

3.24 CABLE TROUGH

A. Contractor shall perform field verification relative to the vehicle dynamic envelope, elevations, clearances, accessibility as well as other elements in the area of work to avoid potential conflicts and allow an easy access for maintenance prior to finalizing locations for the installation.

B. Cable trough shall be kept free of construction debris. Foreign material inside the cable trough shall be removed prior to installation of cables and covers.

C. Cable trough shall not be left uncovered, Contractor shall install the furnished trough covers.

D. Cable trough shall be protected against deformation and damage during construction. Contractor shall avoid placing heavy construction loads immediately adjacent to trough body without providing appropriate protective measures.

E. Where Civil Plans and cross-sections indicate a changing vertical profile, the cable trough shall follow the final grading.

F. Cable trough shall be installed per manufacturer’s installation instructions and recommendation.

G. Gaps between sections of trough and between covers shall not exceed 1/4”.

H. Cable trough shall be inspected for any burrs or rough places that could damage cable insulation. Defected cable troughs shall be repaired per manufacturer’s recommendation or shall be cause for rejection.

I. Where required, cable trough units shall be cut with special cutting equipment recommended by the manufacturer to adjust for lengths and angles. The cut ends shall be joined by a method recommended by the manufacturer to prevent vertical and lateral displacements.

J. Cable trough design and layout shall be such that it allows for water drainage under the trough.

3.25 GROUNDING AND BONDING SYSTEMS

A. Grounding and bonding shall be in accordance with the Plans.

B. Bonding between poles and pole foundations shall be installed in accordance with the Plans.

C. Ground Connections:

1. Exothermic weld buried and embedded ground connections: Make welds in accordance with manufacturer’s requirements. Clean and coat with tar epoxy before backfilling. Welds shall only be performed by welders experienced in the use of the exothermic welding method.

2. Pole grounding in ballasted/sidewalk areas shall conform to details and procedures shown on the Plans.

3. Ground risers from the TPSS grounding grid shall be connected to the TPSS ground stations at locations indicated on the supplier's drawings.

4. No mechanical splices will be allowed in grounding conductors.

D. Ground Rods:

1. Drive ground rods Vertically into the earth with rod top a minimum of 6 inches below grade. Use ground rod as indicated for main grounding system. If extensive rock formation is encountered, relocate ground rods as approved by VTA.

2. Interconnect ground rods with 4/0 AWG bare conductor using exothermic weld connections only.

E. Conduct testing in accordance with approved procedures. Schedule the testing sufficiently in advance to permit observation by VTA or its representative. Prepare and submit test reports promptly. Correct deficient installations as indicated and retest. Continue cycle until acceptable results are obtained.

F. Test Procedure:

1. Contractor shall be responsible for providing a grounding system test procedure and all the necessary instruments and personnel to perform the tests.

2. Test Locations:

a. Each discrete ground location shall be tested to determine if the maximum resistance to ground is equal to or less than 5 Ohms in the case of surge arresters; 10 Ohms or less in the case of poles with dropping resistor assemblies; 25 Ohms in the case of regular pole grounding; and 2 Ohms or less in the case of the substation ground grid.

b. Where specific values are not indicated, Contractor shall follow procedures outlined in the IEEE guides and tabulate values encountered for further action by VTA.

3.26 OCS STRUCTURE NUMBERING

A. All OCS Poles and Structures shall be clearly and permanently numbered, using the reference numbers shown on the OCS layout drawings in the Plans using lettering with the following characteristics:

1. Letter Finish Material: Arlon Reflecta-Cal Series 2400, or VTA-approved equal.

2. Letter Height: 3 inches.

3. Letter Color: Reflecta-Cal Series 2400 Number 06 Yellow on Black Background.

4. Font: Helvetica Compact.

5. Stroke: 5/8 inches.

B. Text Configuration: Numbering characters shall be read vertically, top to bottom, with letters preceding numbers. Exclude any decimal points. For example, numbering of pole number 1004D would read "D1004," from top to bottom.

C. The poles and structures shall be numbered as follows:

1. Side poles located immediately outside of LRT tracks and center poles located between LRT tracks shall have numbers on 2 sides, each facing the oncoming LRT vehicles.

2. Numbers shall be installed 8 feet above track level. In areas of low illumination, luminous numbers or background shall be employed as required to improve visibility.

3.27 REPAIRS

A. Report damage to Resident Engineer and provide a reason for damage to the equipment.

1. Provide a proposed repair procedure or remove and replace damaged components.

2. No repairs of insulators will be allowed, replace all damaged insulators prior to turn over of system.

3. Damaged parts that have been replaced shall be removed from the site.

4. Make repairs to the OCS only as approved by Resident Engineer.

B. Contact Wire Repair.

1. Vertical Kinks:

a. Remove using a leather, copper faced hammer, hydraulic actuated crimping tool, or other approved method/tool by Resident Engineer.

b. Beat the contact wire with the hammer against a flat smooth surface such as a hardwood block.

2. Lateral kinks: not acceptable.

3. Correct twists in the contact wire.

4. Resident Engineer will determine whether contact wire repair is satisfactory.

5. Replace contact wire that cannot be repaired to the satisfaction of the Resident Engineer.

C. Galvanizing Repair.

1. Damage to the galvanizing of poles, brackets and steady arms shall be repaired by the brush application of suitable zinc-rich, cold galvanizing repair paint, ZRC Cold Galvanizing Compound, or an approved equal.

a. Spray application is not allowed.

2. Surface preparation and application of the galvanizing repair shall be in accordance with the repair material manufacturer's recommendations.

3. Other components with damaged or defective galvanizing shall not be installed and shall be removed from the construction site.

4. Work associated with galvanizing repair will be at Contractor's expense.

D. Touch-up Grouting.

1. All work associated with touch-up grouting will be at the Contractor's expense.

3.28 INTERFACE WORK WITH THE EXISTING SYSTEM

A. Work by Contractor in the area of interface with the existing system at TPSS #28 shall require close coordination with VTA. All issues of access and potential impact on VTA operations shall be processed in accordance with special conditions. Complete service interruption on the existing LRT system will be limited to the hours of 01:00 a.m. to 4:00 a.m. while single track operations will be permitted during other hours. Modification of existing catenary arrangement at the interface area shall be as shown on the Plans.

B. Staging Plans shall be submitted by Contractor, at least 30 days before beginning work at the above designated areas, for approval by VTA.

C. Interface work with the existing system shall include but not be limited to:

1. Installation of temporary assemblies as show on the Plans:

a) Temporary down guy foundations and down guy anchor assemblies.

b) Temporary counterweight assemblies.

c) Temporary cantilever arms.

d) Temporary in-span insulators.

2. Temporary modifications of the existing OCS system to accommodate proposed construction work.

3. Removal of all temporary assemblies, abandoned structures and their respective assemblies, as shown on the Plans.

D. All permeant structures and their respective assemblies as shown on the Plans shall not be considered as work involved with the Interface Work with the Existing System, but shall be considered as work involved with the various contract items listed in these Technical Specifications and Contract Drawings.

E. Contractor shall be responsible to ensure that the completed installation complies with the acceptance requirements for the overhead contact system as specified in Section 34 23 69, "OCS and TES Interface Testing and Commissioning." The new and existing catenaries shall be installed and adjusted, as required, as shown on the Plans.

F. Contractor shall clean and restore any areas disturbed during construction and remove excess, demolished or unused materials in the area.

END OF SECTION 34 23 53

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SECTION 34 23 69

OCS AND TES INTERFACE TESTING AND COMMISSIONING

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for final testing and commissioning of the Overhead Contact System (OCS), testing of the portion of the Traction Electrification System (TES) under this contract, and the furnishing of acceptance measurement and test equipment required for the tests.

B. Contractor shall furnish the following items for acceptance measurement and testing:

1. Two insulated telescoping height measuring sticks, calibrated in inches and feet.

2. Two optical stagger gauges, calibrated in inches.

3. One mobile height and stagger gauge, constructed and furnished as an integral unit on a track mounted cart or trolley.

C. The tests specified herein are considered to be an absolute minimum. Contractor shall be responsible for assuring that each design and performance requirement of this Specification is assigned to a specific test effort. Contractor shall furnish a comprehensive test plan as specified. Contractor and its subcontractors may perform additional testing, as they deem necessary.

D. During construction and acceptance measurements, the acceptance measurement and test equipment shall remain the property of Contractor, and be used by Contractor and VTA. Upon contract completion, equipment shall be turned over to VTA in good working condition.

E. Contractor shall provide necessary assistance in the performance of TPSS-related tests and during the system integration tests.

1.02 REFERENCED STANDARDS

A. American National Standards Institute (ANSI):

1. C29.1 Test Methods for Electrical Power Insulators

B. State of California Public Utilities Commission (CPUC):

1. G.O. 95 Rules for Overhead Electric Line Construction.

1.03 SUBMITTALS

A. Contractor shall submit the following:

1. Résumés of field service engineer and instructors.

2. Detailed outline of the training course with hourly lesson Plans. The course outline shall include lists of course materials, training aids, and necessary training equipment.

3. Training schedule.

4. Field service engineer's logs.

B. Test Program Plan: Contractor shall submit a Test Program Plan (TPP) for acceptance within 110 days of the Notice of Award. The purpose of this plan is to ensure that Contractor has considered all of the testing requirements contained in this and other sections of these technical specifications, and has made adequate provisions for testing in his overall program Plans and schedules, and to achieve an early mutual understanding between Contractor and VTA on the range, depth and other aspects of tests to be conducted. The Test Program Plan shall contain as a minimum the following data:

1. A flow diagram indicating the logical sequence of tests, starting with factory tests and continuing on to conclude with field demonstration tests.

2. A list of test procedures (by test procedure number) to be submitted, preliminary submittal schedule, a preliminary schedule of tests, and a brief description of each factory and field test. The schedule portion of the Test Program Plan shall be a dynamic document to be updated as the program progresses.

3. An outline and format of the procedure and test data sheets for each type of test.

4. Requirements and recommendations for witnessing by VTA or its designated representative.

5. A description of Contractor's in-plant and field-test organization.

6. A detailed Safety Program defining all precautions to be taken, notices, signs and barriers to be posted concerning the safety of the public, work personnel and equipment. The program shall define precautionary measures to be taken before, during and following the test until such time as normal work is resumed.

C. Test Procedures: Test procedures shall be submitted to VTA for acceptance at least 45 days in advance of the scheduled test. The test procedure shall include, as a minimum: Objective and scope; test set-up; test equipment to be used; personnel required for the test; estimated duration of the test; pass/fail criteria; and samples of data sheets to be used. All tests must be performed in accordance with the test procedures. Deviations will not be allowed unless accepted by VTA.

D. Test Reports: 6 certified copies of Test Reports shall be submitted for acceptance within 15 days after completion of tests. Test reports shall contain all the data obtained during tests, an analysis of the data and conclusions relating to the test pass/fail criteria outlined in the test procedure. A test that fails shall be repeated, and any corrective action taken to pass the re-test shall be outlined in a new test report.

E. Types of Tests: The types of tests to be covered in the Test Program Plan shall include those required for testing and commissioning the Overhead Contact System following completion of construction, as specified hereinafter in Part 3 of this Section. The following commissioning tests are required:

1. Acceptance measurements.

2. Visual inspection of completed OCS.

3. Clearance envelope tests for pantograph and vehicle.

4. Overhead contact system electrical tests.

5. Live line run testing.

6. Operational test of disconnect switches and voltage sensing system.

F. Insulated Telescoping Height Measuring Sticks: Contractor shall supply a catalog cut of the specified insulated telescoping height measuring stick, or a complete technical description of any proposed alternative.

G. Optical Stagger Gauges: Contractor shall supply complete catalog information on the specified optical stagger gauges, or shop drawings and a working description of any proposed alternative.

H. Mobile Height and Stagger Gauge: Contractor shall supply shop drawings and outline specifications for the mobile height and stagger gauge, fully describing the following:

1. Materials used.

2. Construction.

3. Assembly/disassembly.

4. Operation without clearance "ears."

5. Installation of clearance "ears," and safeguards for use.

6. Track super-elevation compensation.

7. Means for keeping gauge in adjustment.

8. Proposed spare parts.

1.04 PERFORMANCE OF TESTING

A. OCS system and its components shall be tested to verify compliance with Contract performance, reliability, and maintainability requirements.

B. Tests described in this Section shall be performed as indicated unless specifically waived by VTA. Tests shall be performed on production components without modification or special preparation.

C. After the OCS has been installed and is to be made ready for operation, field installation and system testing shall be performed to verify physical and electrical integrity of the system and to verify quality of workmanship.

D. Factory design or production testing of individual components shall be performed by component manufacturer at the plant of manufacture or at a testing facility as approved by VTA.

E. Field installation and system testing of each of the newly installed OCS tension sections or partially modified or extended tension sections shall be performed by the OCS installer under direct supervision of a field service engineer representing the manufacturer of OCS equipment and Contractor.

F. Field testing of insulated power cables rated 2 kV and higher shall be performed by a National Electrical Testing Association (NETA) certified technician working for an independent testing company under direct supervision of manufacturer of the substation equipment and hired by manufacturer of substation equipment.

1. NETA technician shall have at least 5 years of experience in construction acceptance testing of similar equipment.

2. Testing company shall be a NETA member and shall be approved by VTA.

3. After VTA approval, testing company shall not be discharged or otherwise replaced without written approval of VTA.

G. Following completion of all field installation and system testing, LRV tests shall be performed to demonstrate clearances and commutation without arcing. LRV testing of complete OCS installation shall be performed by OCS installer under direction of a field service engineer representing the manufacturer of OCS equipment and Contractor.

1.05 QUALITY CONTROL

A. Contractor shall perform the following:

1. Material qualification testing and certification for acceptance of materials, components and assemblies.

2. Job control testing of in-progress work being performed in shops, factories and on-site.

3. On-site inspection of specified work elements.

B. Federal, State and Local Authorities: Conform to applicable codes and regulations.

C. Quality Assurance shall be in accordance with the provisions of Special Conditions, Section 6.26 “Quality Assurance and Quality Control Requirements.”

1.06 MEASUREMENT AND PAYMENT

A. Measurement: OCS and TES Testing and Commissioning shall be measured by the lump sum (LS) price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump (LS) sum payment for OCS and TES Testing and Commissioning shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in OCS and TES Testing and Commissioning, and support services during system integration testing, complete in place, including personnel and services, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 MATERIAL

A. General:

1. Contractor shall provide tools, instruments, calibration devices, meters, and other equipment necessary to connect, monitor, and adjust during start-up and testing.

2. Contractor shall provide spare parts as required to conduct the start-up and testing.

3. Contractor shall furnish the height and stagger gauges, and all other equipment and personnel services necessary to make Acceptance Measurements. Contractor shall also provide all the electrical equipment and personnel services required to perform the TES electrical tests. All measuring equipment will be as accepted by VTA.

B. Insulated Telescoping Height Sticks: Hasting model with carrying case or VTA approved equal, 30 feet extended length, 50 inches collapsed length, marked in English gradations.

C. Optical Stagger Gauges: Each comprising a measuring rod, an adjustable measuring bar, and a lens carriage called an "optic", to read in English units, and equipped for night measurement with built-in lighting and spare batteries.

D. Mobile Height and Stagger Gauge: Vehicle mounted, with demountable clearance "ears," shall be custom fabricated in accordance with the requirements described in Section 34 23 26, "Special Tools," Article 2.03, "Height/Stagger Gauges," of these technical specifications. The unit shall include a rigid tow bar for coupling to a track mounted "bucket" truck, and shall comply with VTA requirements for insulation between rails.

PART 3 – EXECUTION

3.01 FIELD SERVICE ENGINEER

A. Contractor shall provide the services of a qualified field support engineer at the project site, to assist as required during startup and system integration testing.

B. Upon approval, the field service engineer shall advise VTA on traction power system energization and start-up.

C. The field service engineer shall have a thorough knowledge of the overhead contact system as well as installation, start-up, and testing requirements for all components furnished under this Contract.

D. The field service engineer shall be available on site 5 working days after notification. Weekly logs shall be maintained and submitted. Logs shall show tasks performed with dates and duration.

3.02 START-UP

A. Upon successful completion of the testing, adjustment, and calibration as specified in and as indicated in the sections pertaining to the components of the traction power and overhead contact system, VTA shall be notified when each line section is ready for energization. Ten working days subsequent to the notification, VTA will complete arrangements for the provision of power by the utility company concerned.

B. When approved by VTA, each line section shall be energized.

3.03 SUBSTATION FIELD TEST SUPPORT

A. Contractor shall provide substation field test support to include:

1. Provision and connection of testing equipment in accordance with the system test plan.

2. Calibration and adjustment of protective devices in accordance with equipment manufacturers' instructions.

3. Witnessing the testing.

4. Disconnecting testing equipment when testing is completed.

B. Contractor shall advise VTA regarding test procedures, analysis of results, and recommended corrective actions.

3.04 TRAINING

A. Contractor shall provide two 5-day on-site training classes to VTA's personnel in the operation and maintenance of the Overhead Contact System.

B. Contractor shall schedule the personnel-training course after delivery of operation and maintenance manuals and 120 days before the start of integrated system testing. The exact starting date for the personnel training course will be as directed by VTA. The personnel-training course shall be scheduled between 8:00 AM and 5:00 PM, Monday through Friday.

C. Contractor shall establish an objective grading system to report the progress of each trainee during the course. Grading shall be kept confidential and furnished only to personnel designated by VTA.

D. Space for classroom lectures and practical training on equipment and training equipment such as slide projectors, movie projectors, screens, easels, and similar equipment will be furnished by VTA.

E. Contractor may use spare parts furnished under this Contract as training aids and for demonstration of and practical exercises for adjusting, testing, disassembly and assembly of equipment. Contractor shall ensure that the spare parts used for training are repackaged and returned to storage in acceptable condition for installation in the system.

F. Contractor shall provide practical training on the installed Overhead Contact System.

G. The contents of the operations training course shall include, as a minimum, description of procedures and in-service training or simulation for placing system into initial operation, making necessary adjustments while equipment is in operation and shutting down the equipment. It shall also include trouble shooting procedures and thorough instruction in emergency procedures. This course shall be directed toward engineers and journeyman electricians who are experienced in operation of AC electrical equipment, but who do not have prior experience in operation of DC electrical equipment used for rapid transit systems. The course shall prepare the trainee for operation of the equipment.

H. The contents of the maintenance training course shall include, as a minimum, review of basics of safety and electrical equipment maintenance; and classroom description and in-service training on maintaining, testing, trouble shooting, adjusting, assembling and disassembling all items of equipment. In addition, the training shall include instruction on interpreting the plans, special rigging requirements for repair to tensioning equipment, troubleshooting excessive arcing, repair to curves and spider webs. This course shall be directed to technicians comparable to journeyman electricians who do not have prior experience in maintenance of overhead contact systems. The course shall prepare the trainee for maintenance of the Overhead Contact System.

I. Any printed material or audio-visual material prepared by Contractor as teaching aids shall become the property of VTA at the completion of the training program.

J. Class size for both courses is estimated to be 15: 5 supervisory engineers and 10 technicians.

3.05 TEST PROCEDURES AND EQUIPMENT

A. The acceptance measurement and test equipment will be used by Contractor and VTA for checking the location of the contact wire, and verifying that the registration assemblies conform to the clearance requirements of the pantograph clearance envelope, as shown on the Plans. Each item of equipment will be used as follows:

1. Insulated telescoping height measurement sticks will be used to measure the heights of conductors and guys, track clearances to undersides of catenary structures and other installed details.

2. Optical stagger gauges will be used to verify the measurements given by Contractor in the Acceptance Measurement Form.

3. The mobile height and stagger gauge will be used only on electrically de-energized catenary, and for the following purposes:

a. To check visually the location (height and stagger) of the contact wire throughout the completed new electrified lines.

b. To confirm that the contact wire registration assemblies are installed in conformance with the requirements of the pantograph clearance gauge.

B. One insulated telescoping height measuring stick, and 1 optical stagger gauge, shall be readily available for use by VTA at any time during the construction and acceptance measurement periods.

C. All measuring tapes, poles, and sticks used to collate data when the OCS is energized shall be non-conducting. Do not use metallic or conductive measuring tapes, chains, and other devices.

3.06 ACCEPTANCE MEASUREMENTS

A. Upon completion of each tension segment, Contractor shall measure the contact wire height, stagger, and other required dimensions and record the readings on an Acceptance Measurement Form, in the presence of VTA.

B. The Acceptance Measurements Table shall be prepared as shown in the attached Table A-1, and shall include the following information:

1. Track designation.

2. Wire run number as indicated on the layout schedule.

3. Drawing numbers where the structures of the wire run are shown.

4. Names of persons responsible for performing the acceptance measurements.

5. Sheet number of a wire run set.

6. Equipment or catenary style being measured.

7. Temperature of the conductor in degrees Fahrenheit during the time of measurement.

8. Weather condition during time of measurement (e.g., windy, raining).

9. Date when measurement was made.

10. Structure number identification.

11. Station location of the structure as indicated on the OCS Layout Schedule.

12. Distance of the pole to the rail measured from the inside of the nearest rail to the face of the pole.

13. Height of the foundation relative to the rail measured from the top of the nearest rail to the top (crown) of the foundation.

14. Cross-level difference of the 2 rails measured at the structure station (actual superelevation at the structure).

15. Distance measured at the structure from the contact wire to the vertical or superelevated centerline of the track (referred to as stagger). Record as left (L) or right (R) of centerline when viewed in direction of increasing stationing.

16. Same as 15, except for out-running where applicable.

17. The vertical distance of the contact wire at the structure measured from the top of the highest rail (referred to as contact wire height at the support).

18. Span length, as measured between OCS supports.

19. Cross-level difference of the 2 rails measured at midspan (referred to as actual superelevation at midspan).

20. Distance between the contact wire and the vertical or superelevated centerline of the track measured at midspan (referred to as midspan offset). Record as left (L) or right (R) of centerline when viewed in direction of increasing stationing.

21. Same as 20, except for out-running where applicable.

22. The vertical distance of the contact wires at midspan measured from the top of the highest rail (referred to as contact wire height at midspan).

23. The average of the contact wire heights of the structures at each end of the span minus the contact wire height at midspan (referred to as pre-sag).

24. Same as 23, except for out-running where applicable.

25. The rate of change of contact wire height between the structures. This is equal to the difference of contact wire heights at each structure divided by the span (referred to as gradient).

26. Vertical distance measured at the structure between the contact wire and the messenger wire.

27. Rise or fall of counterweight from median position.

28. For counterweight: Ambient temperature.

29. Positions of counterweight stops.

30. The vertical distance between overhead obstructions and the track at the vertical or super-elevated centerline of the track position.

31. Electrical clearance from messenger or contact wire support (or the conductors at the minimum clearance position) to overhead obstructions, with uplift force of 50 LBS on the contact wire at the point of measurement.

32. At overlaps and turnouts: Height of in-running and out-of- running contact wire above rail-referenced level at each structure (separate columns are provided for in-running and out-of-running contact wire).

33. Comments or remarks as required.

C. VTA will use the Acceptance Measurements to determine compliance with the design and will inform Contractor of necessary corrections.

D. Contractor shall execute corrections at no further cost to VTA, except for adjustments required by VTA that are changes beyond the requirements specified in the Contract Documents.

E. After execution of corrections, Contractor shall re-measure and record affected data and submit the results to VTA.

F. The work of this Section will not be complete until corrections are completed and accepted by VTA.

G. Completed Acceptance Measurement Tables shall be submitted in accordance with the requirements.

3.07 VISUAL INSPECTION OF COMPLETE OVERHEAD CONTACT SYSTEM

A. At contact wire level, Contractor shall make the following checks, and remedy unsatisfactory conditions uncovered therein:

1. Check fit and tightness of all components.

2. Check split pins and locknuts are secure.

3. Check contact wire for kinks, rolls and damage.

4. Check messenger wire for damage to strands.

5. Check correct steady arm fittings.

6. Check heel settings.

7. Check that jumpers are of correct type, have adequate travel capability, are properly fitted and are well formed to reduce fatigue failure.

8. Check posture of pulley plates.

9. Check that hinge fittings have freedom to move under load.

10. Check that a wire passing through a cantilever and not attached to it will clear any part of this cantilever by at least 3 inches throughout the temperature range of 25°F to 130°F.

11. Check clearance between adjacent or crossing catenaries.

12. Check installation at locations of possible interference with passage of pantographs to ensure that proper mechanical clearance is maintained at registration, and that the pantograph will ride smoothly across crossing wires and insulated units without entanglement.

13. The Contractor shall make available a high-rail platform truck to allow VTA to participate in the visual inspection of the OCS prior to running the dead car test.

B. From the Ground, Contractor shall make the following checks:

1. Check that counterweights have freedom to travel and that counterweight band does not bear on pole walls.

2. Check that cantilevers have correct along-track offset.

3. Check that hangers are plumb and within design position.

4. Check out safety requirements in accordance with CPUC G.O. 95 and other applicable safety codes.

3.08 CLEARANCE ENVELOPE TESTS FOR PANTOGRAPH AND VEHICLE

A. General: The purpose of these tests is to verify the mechanical and electrical clearances of the light rail vehicle (LRV) units on each section of the system. The tests shall be conducted after all installations are complete. Any section found to have insufficient clearance should be adjusted to provide the required clearance.

B. Pantograph Clearance Envelope: Tests shall be performed initially with a rail mounted height and stagger gauge having the same profile as the vehicle pantograph. This gauge shall be used to verify the mechanical clearances between the pantograph and OCS components such as the heels of steady arms and contact wire clamps, and the electrical clearances between the OCS/pantograph combination and civil structures such as over bridges. Following these tests, final tests shall be performed with an actual LRV to verify the initial simulated results.

C. LRV Clearance Envelope: Tests shall be performed with an LRV through each track section. The following tests shall be performed:

1. Dead Slow Tests at Walking Speed: The driver of the LRV unit shall be prepared to stop at short notice during these tests.

   a. Trackside Structural Clearances to LRV Body and Pantograph: This includes poles, bridges, tunnels, awnings, wayside signaling and electrical equipment housings.

   b. LRV body clearances shall be checked at:

      1) The ends of each unit.

      2) The midspan between trucks.

2. Contractor is to coordinate and schedule this test with VTA at least three weeks prior to test.

3.09 ELECTRICAL TESTS FOR THE TES INTERFACE

A. Proper Connections and Circuit Integrity: Contractor shall verify the connections and circuit continuity for all power and control cables between the OCS and the traction power substations. The tests shall comprise both visual inspection and ringing the circuit, and shall include the following:

1. Verifying that each pole-mounted feeder disconnect switch is connected to the correct feeder circuit breaker in the TPSS, and that the jumper cables from the disconnect switch to the OCS are connected to the correct OCS section.

2. Verifying that the control cable from each pole-mounted disconnect switch goes to the appropriate terminal block in the TPSS, and that the labeling and connections to devices at both ends are correct.

3. For disconnect switches equipped with a voltage monitoring circuit, verifying that:

   a. The dropping resistor is connected to the correct OCS section, and the circuit is continuous and properly identified at the TPSS end.

   b. Electrical devices in the enclosure at the switch-operating handle, such as zener diode, regular diode, and fuse are in good working order and properly connected.

B. Loop Resistance Test:

1. General: The purpose of this test is to obtain the DC loop resistance of each OCS section. This test checks both the OCS and the rail return system for electrical continuity and the absence of high resistance connections or inadvertent ground connections. The length of each OCS section shall be in accordance with the system-sectionalizing diagram for normal operations.

2. Procedures:

   a. Feeders that are electrically common to the OCS, such as TPSS power feeders to the OCS section, shall be connected to the OCS. In such case, the measurement or short-circuiting shall be done from the TPSS.

b. A DC source is required which will provide a current of nominally 100 A with an applied voltage of 24 V (e.g., 2 car batteries in series).

c. Measurements shall be made of the DC voltage and DC current, the circuit resistance calculated from the measured values of voltage, and current shall be compared with the design value.

d. Any section having a discrepancy of more than 10 percent between the calculated design value and the measured value shall be rechecked to ensure that all electrical connections are correctly made, or that there are no inadvertent ground connections to the OCS which are reducing the total length of the loop. Contractor shall investigate the cause of any unusual discrepancy between the design and measured resistance values, and shall inform VTA accordingly.

e. DC voltage shall be applied as shown in attached Figure C-1.

f. The following items shall be recorded for each section, using attached Table C-1:

1) Length of section in kilometers

2) DC volts

3) DC amperes

4) Ohms

5) Ohms per 1000 feet

3. Precautions: The tests required for the loop resistance require passing relatively high DC currents through the OCS and rails. Proper regard must be paid to safety. Test zones shall be clearly identified and coordinated with other parties working in the vicinity of the tests to provide a safe environment. All safety requirements established in the safety program concerning the public, work personnel, and equipment shall be strictly enforced. Personnel not directly associated with the tests shall stay clear of the tracks. The section of OCS and associated feeders under test shall be isolated from the adjacent sections of the system.

C. Hi-Potential Test for the OCS:

1. General: DC Hi-pot tests shall be performed on the Overhead Contact System (OCS). Hi-pot tests serve the following purposes:

a. Components such as insulators and jumper cables are checked for leakage.

b. The electrical withstand of minimum clearance areas, such as overhead bridges, are verified under static conditions.

c. The electrical withstand of section insulators and disconnect switches are verified.

d. The test provides a means of periodically checking for any reduction in the insulation level of the OCS sections, by comparing voltage and leakage current with previously measured values.

1) A nominal DC Hi-pot voltage of 2 x OCS rated voltage + 1 kV shall be used for the test. Hi-pot tests shall be carried out on the OCS sections as soon as possible after the continuity tests have been completed, to ensure that all of the section being tested is electrically continuous and is subjected to the test voltage. Leakage currents between 0 and 5 mA can be expected for section lengths of one to two miles.

2) Procedure: Feeder disconnect switches shall be set in the open position. The adjacent OCS sections that are electrically isolated from the section under test shall be grounded by connecting the OCS to the rails. All surge arresters shall be disconnected from the section under test. A DC test voltage shall be applied to each OCS section in 500V increments up to the top nominal test voltage. The test voltage shall be held for 30 seconds at each increment. Then hold the Hi-pot at the top Kv level for 3 minutes. Circuit connections shall be as shown in attached Figure D-1. The leakage current at each value shall be measured and recorded as shown in attached Table D-1, together with the weather conditions and temperature.

3) Precautions: The Hi-pot measurements require application of high voltage to the OCS. Proper regard must be paid to safety. Test zones shall be clearly identified and coordinated with other parties working in the vicinity of the tests to provide a safe environment. All safety requirements established in the safety program concerning the public, work personnel, and equipment shall be strictly enforced. Personnel not directly associated with the test shall be clear of the tracks. Sections of OCS and associated feeders under test shall be isolated from the adjacent sections of the system and all OCS sections adjacent to the section under test shall be grounded.

D. High-Potential Test for the Feeder Cables:

1. Contractor shall hi-pot the existing (interface with existing system) and new DC feeder cables after they have been installed in the underground ductbank and spliced, where required. For the hi-pot test, the ends of the feeder cable shall be disconnected from the equipment where they are normally terminated. The hi-pot field test of the feeder cable shall be in accordance with the instructions, methodology, and criteria furnished by the cable manufacturer to Contractor.

E. Ground Resistance Measurement:

1. General: The purpose of this test is to measure the ground resistance of the following:

a. Each OCS pole with a grounding system furnished and installed by Contractor.

b. Each surge arrester with a grounding system furnished and installed by Contractor.

c. Each substation grounding grid.

2. Procedure:

a. The ground resistance megger shall be connected as shown in the attached Figure B-1. The lead from P_1/C_1 shall be as short as possible, and the electrodes and the ground rod should be in a straight line. It is not essential that the electrodes be paralleled to the track, but this configuration will probably be the most convenient.

b. The electrodes shall be positioned at distances as shown in attached Table B-1 Test Position 1, i.e., with x = 65 feet and y = 105 feet. Current and potential electrodes shall be inserted into the earth to about 6 inches to 10 inches. For very dry soil, water shall be poured around the current electrodes. To ensure acceptable values of resistance, the ratio of distances (x/y) shall be approximately 0.62. The resistance shall be measured and recorded.

c. Keeping the x dimension the same as in step b, the current electrode shall be repositioned to (y + 6.5) feet (Test Position 2), and the resistance measured and recorded.

d. The resistance values obtained in steps b and c shall be compared. If the readings obtained are within 5 percent of each other, no further measurements are required, and the average value shall be used as the actual resistance. If the readings differ by more than 5 percent, x shall be increased by 10 feet and y made equal to (x + 10)/0.62 approximately (Test Position 3), and steps b, c, and d shall be repeated as necessary.

e. In the case of a surge arrester, each location shall be tested and a measured ground resistance value of 5 Ohms or less is desirable. Values ranging between 5 Ohms and 20 Ohms may be acceptable subject to VTA's approval. Values greater than 20 Ohms (or per VTA's discretion, greater than 5 Ohms) shall require remedial action.

f. In the case of pole grounding, a measured ground resistance of 25 Ohms or less is acceptable for a regular pole, and 10 Ohms or less for a pole with a dropping resistor assembly.

g. Substation grounding grid resistance shall be measured using the Fall-of-Potential Method. Acceptable resistance value shall be 5 Ohms or less.

3. Remedial Action: The measured resistance of the grounding system shall meet the specified criteria. Otherwise, remedial action is required on the part of Contractor, such as chemical treatment of the soil around the ground rods, or extension of the grounding system and the addition of extra ground rods.

3.10 LIVE LINE RUN TESTING

A. The live line run testing is not the responsibility of the Contractor. The Contractor shall provide support during the performance of the test.

B. General: The purpose of these tests is to evaluate:

1. The current collection performance between the LRV and the OCS.

2. The adequacy of the power supplied by the OCS for required vehicle performance.

C. Procedures:

1. Current collection performance tests shall be performed at LRV speeds in increasing increments up to the in-service speeds permitted by track speed limits. LRV test speeds shall not exceed the specified track speed limits or as directed by the Public Utilities Commission regulations for test vehicles.

2. During the current performance tests, particular attention shall be paid to:

a. Behavior of the pantograph on various contact wire profiles for signs of loss of contact.

b. Overlaps, crossovers, turnouts, bridge approach spans and section insulators for smooth running and takeover.

c. Take-over points at overlaps, crossovers, turnouts and section insulators for smooth transitions.

d. Dynamic clearances at bridges/tunnel fittings, facias, crossing and parallel contacts, clearances to uplifted steady arms and supports.

e. Midspan offsets, stagger effects and contact wire sweep.

3. Locations where problems are observed shall be recorded and submitted to VTA for its recommendations on corrective action. Contractor shall implement VTA's recommendations.

4. Contractor shall provide equipment for recording of the current collection performance tests. These tests shall be supplemented by video-taped recordings to facilitate detailed analysis of the OCS after the tests have been made.

5. If adjustments are made to the OCS or to track alignment after the initial tests, the tests shall be repeated on the affected sections at no cost to VTA, and their results documented in the same manner as detailed in the preceding paragraphs.

3.11 OPERATIONAL TEST OF DISCONNECT SWITCHES AND VOLTAGE SENSING SYSTEMS

A. Perform these tests to evaluate the following:

1. Adequate operation of the disconnect switches including the indications of switch positions.

B. Performance of the voltage sensing system including dropping resistor, protective devices, relay and the associated wiring.

C. Procedures:

1. Operate each disconnect switch in its open, closed, and intermediate position a minimum of 5 times.

2. Verify correct operation of disconnect switches for positions specified in Article 3.11.A.1 by monitoring the supervisory interface terminal cabinet (SITC).

3. During test specified in Article 3.10, monitor the operation of the voltage sensing system to verify input signals to the monitoring relay. At each substation location, verify pick-up and drop-out voltages for compliance with these technical specifications, and verify integrity and proper functioning of protective devices.

3.12 ANALYSES OF RESULTS

A. Analysis of test results shall be performed jointly by VTA, the Overhead Contact System designer and the LRV manufacturer.

B. Recommendations of system changes shall be jointly evaluated for feasibility by the above listed parties.

3.13 ACCEPTANCE RECORDS

A. Records shall be made of all tests listed under Articles 3.05, 3.06, 3.07, 3.08 and 3.09 in accordance with the requirements of the:

1. State of California Public Utilities Commission regulations engineer.
2. Overhead contact system designer.
3. Light rail vehicle manufacturer.
4. State of California Department of Transportation (Caltrans).

3.14 SUPPORT DURING SYSTEM INTEGRATION TESTS

A. Contractor shall provide support to VTA during all live line tests and other integrated system tests to be performed as part of the overall integrated test program. An allowance of 100 manhours for labor shall be included in the contract price for this effort. All corrective work to the OCS. system found to be necessary as a result of these tests shall be performed at no cost to VTA and is considered to be part of the overall installation cost.

END OF SECTION 34 23 69

ATTACHMENT TO SECTION 34 23 69

TABLE A-1

FIGURE B-1

TABLE B-1

FIGURE C-1

TABLE C-1

FIGURE D-1

TABLE D-1

TABLE A-1
ACCEPTANCE MEASUREMENTS

TRACK[1]	WIRE RUN No.[2]	DWG No.[3]	NAME(S)[4]		SHEET NO.[5]
	EQUIPMENT STYLE[6]		CONDUCTOR TEMP (°F)[7]	WEATHER[8]	DATE[9]

STRUCTURE								SPAN (FT)[18]	MIDSPAN				SAG & GRADIENT			SYSTEM HT. (FT)[26]	COUNTER WEIGHT		OVERHEAD OBSTRCTNS.		OVERLAPS/ TURNOUTS	
STRC No.[10]	STA-TION[11]	POLE TO RAIL DIST (ft)[12]	FND HT. NEAR RAIL[13]	CROSSLEVEL	STAGGER		CW HT. HIGH RAIL (ft)[17]		CROSSLEVEL	OFFSET		CW HT. HIGH RAIL (ft)[22]	PRE-SAG		GRA-DIENT[25]		TEMP (°F)	#[28]	HT. TO OBST. (ft)[30]	ELEC. CLR (in)[31]	HT. OF I/R & O/R CONTACT WIRE	
				(in)[14]	(in)[15]	(in)[16]			(in)[19]	(in)[20]	(in)[21]		(in)[23]	(in)[24]			RISE OR FALL (in)[27]	POS. OF STOPS (in)[29]			I/R (ft)[32]	O/R (ft)[32]

COMMENTS[33]

FIGURE B-1

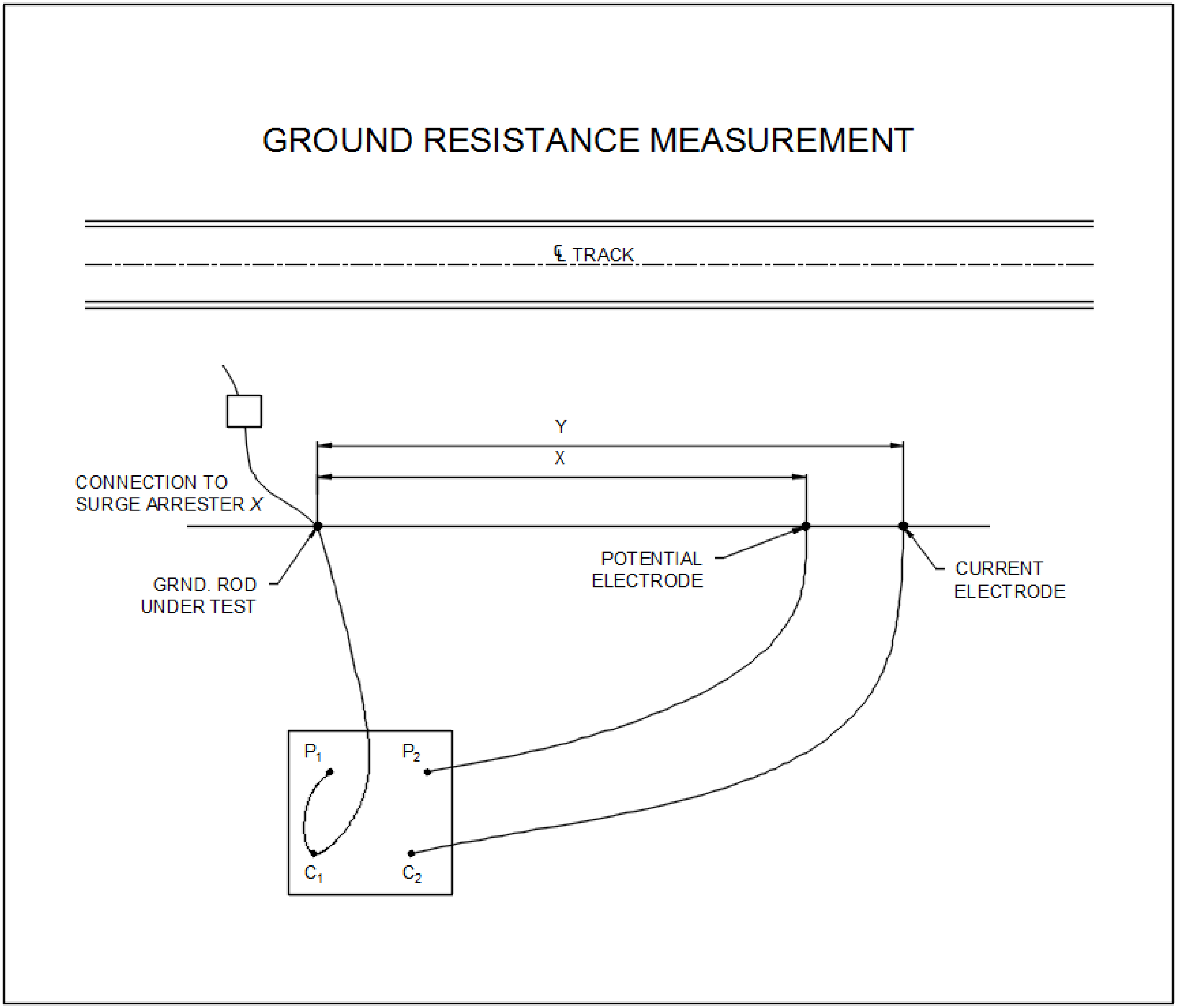
GROUND RESISTANCE MEASUREMENT
℄ TRACK
Y
X
CONNECTION TO
SURGE ARRESTER X
GRND. ROD
UNDER TEST
POTENTIAL
ELECTRODE
CURRENT
ELECTRODE
P1
P2
C1
C2

TABLE B-1

ARRESTER LOCATION	TEST POSITION	DISTANCE X (FT)	DISTANCE Y (FT)	MEASURED GROUND RESISTANCE (Ω)	AVERAGE GROUND RESISTANCE FOR STRC. LOCATION (Ω)
	1	65.0	105.0		
	2	65.0	111.5		
	3	75.0	120.5		
	4	75.0	127.0		

FIGURE C-1

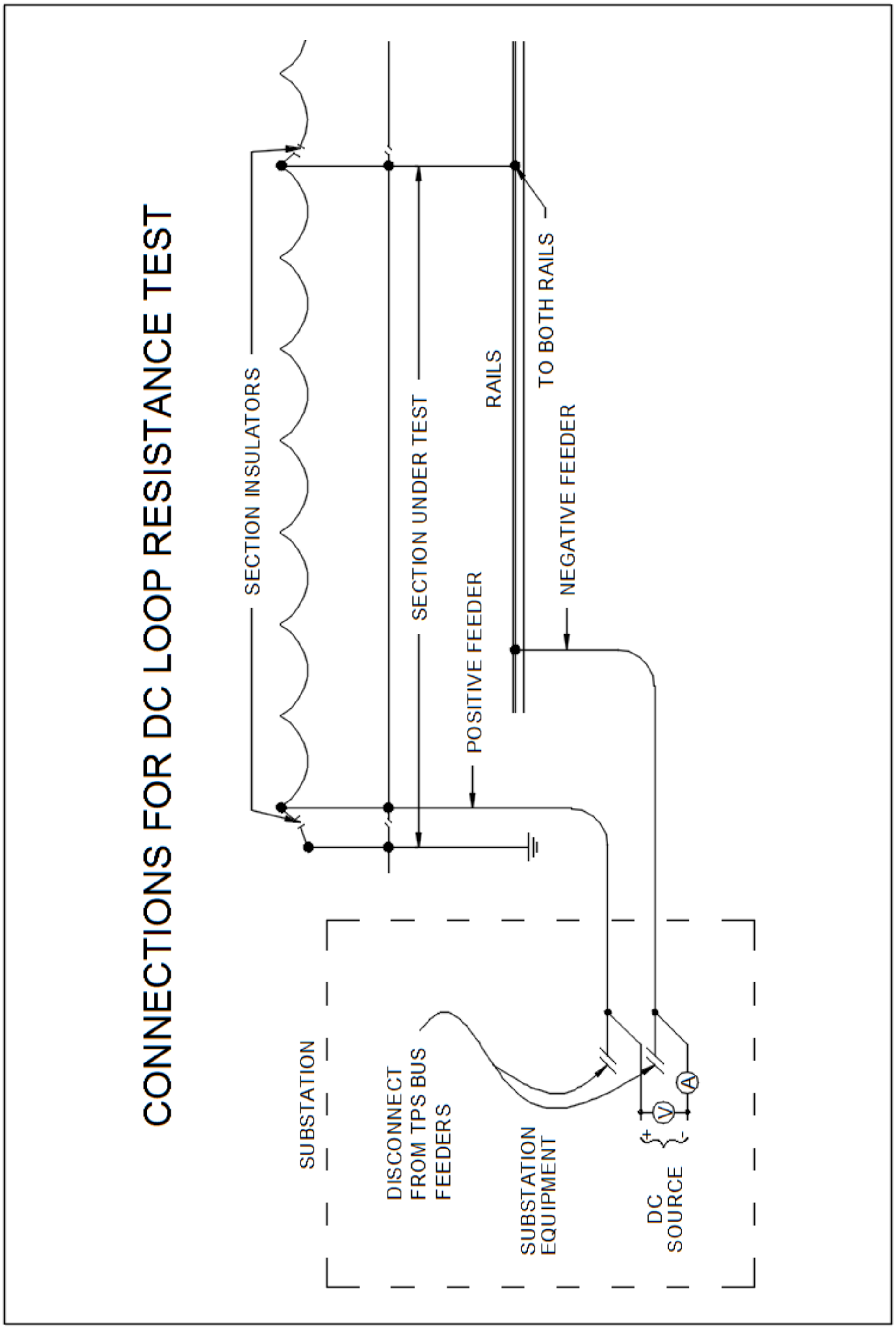
CONNECTIONS FOR DC LOOP RESISTANCE TEST
SECTION INSULATORS
SECTION UNDER TEST
RAILS
TO BOTH RAILS
POSITIVE FEEDER
NEGATIVE FEEDER
SUBSTATION
DISCONNECT FROM TPS BUS FEEDERS
SUBSTATION EQUIPMENT
DC SOURCE
V
A
+
-

TABLE C-1

CIRCUIT CANTINUITY AND LOOP RESISTOR TEST REPORT								
CLIENT:			JOB No.:				TEST No.:	
LOCATION:		TPSS No.					DATE:	
FEEDER DESIGNATION: FROM				TO			TEST ENG.:	
AMBIENT TEMPERATURE:			RELATIVE HUMIDITY:		TEST EQUIPMENT:			
TEST TYPE:	ACCEPTANCE (x)		PRROF ( )	MAINTENANCE ( )	TEST VOLTAGE: 24Vdc (2-12Vdc deep cycle batteries.)			
TEST DATA								
NAME OF FEEDER	TRACK	LENGTH OF SECTION	DC VOLTS	DC AMPS	OHMS	OHMS/1000 FT	DESIGN OHMS/1000 FT	DISCREP (%)
NOTES:				TEST ENGINEER:			DATE:	
				WITNESS:			DATE:	

FIGURE D-1

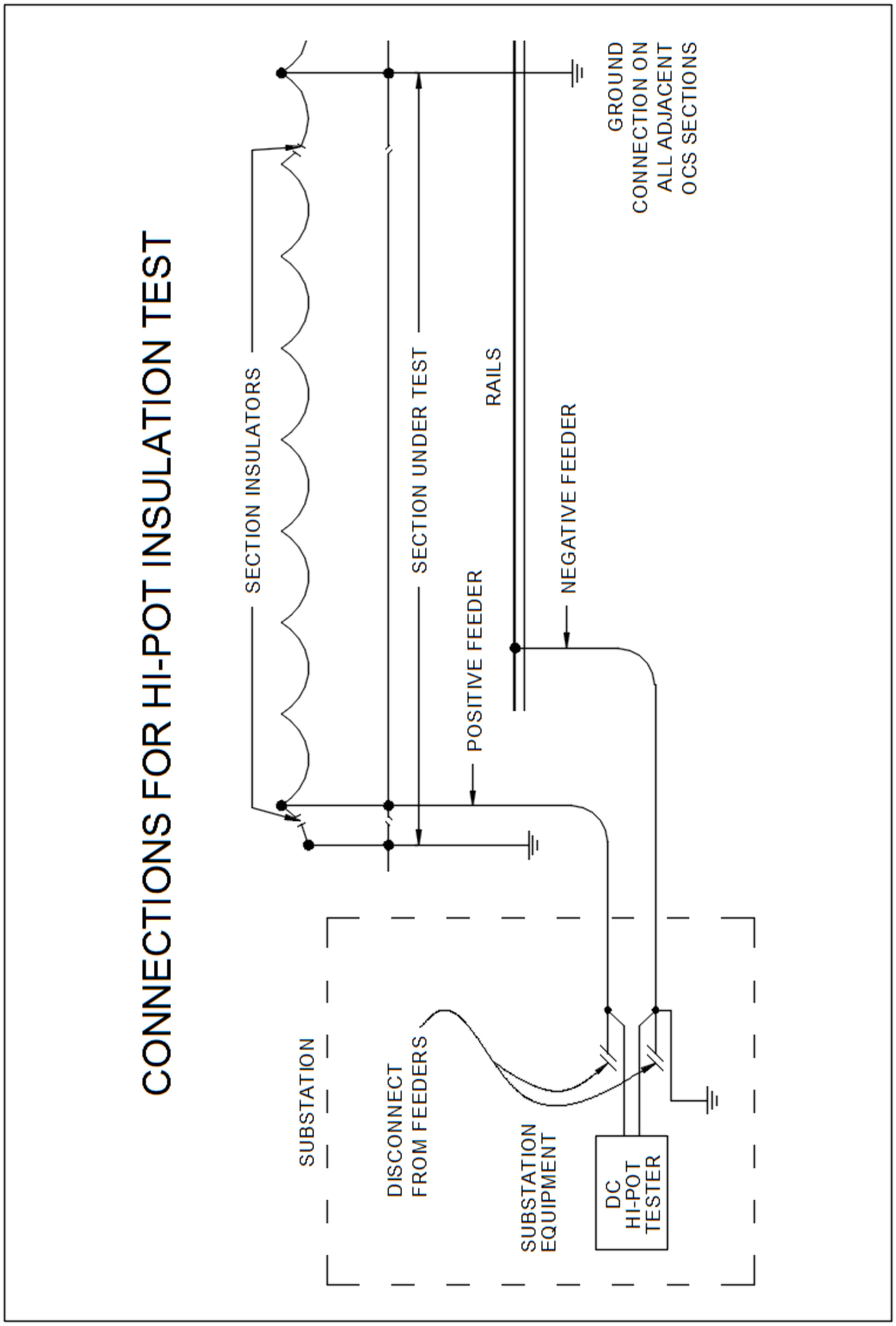
CONNECTIONS FOR HI-POT INSULATION TEST
SECTION INSULATORS
SECTION UNDER TEST
RAILS
POSITIVE FEEDER
NEGATIVE FEEDER
GROUND CONNECTION ON ALL ADJACENT OCS SECTIONS
SUBSTATION
DISCONNECT FROM FEEDERS
SUBSTATION EQUIPMENT
DC HI-POT TESTER

TABLE D-1

DC HIGH-POTENTIAL TEST REPORT		
CLIENT:	JOB No.:	TEST No.:
LOCATION, TPSS No.:		DATE:
FEEDER DESIGNATION, FROM: TO		TEST ENGINEER:

CABLE DATA				
MANUFACTURER:	VOLTAGE RATING:	INSULATION:	CONDUCTOR SIZE:	LENGTH:
DATE INSTALLED:	TERMINATIONS: LINE: NONE	KV STRESS CONE	UNGRD LOAD: NONE	

TEST PROCEDURE				
TEST TYPE:	ACCEPTANCE (x)	PRROF ( )	MAINTENANCE ( )	SPECIFICATION MV90 IPCEA S n/a OTHER n/a
MAX TEST VOLTAGE: KV	VOLTAGE INCREMENTS:		STABILIZATION TIME: 30 sec	CORONA SUPPERSSION: SPHERE
SPACE CHARGE CONTAINMENT: ( ) RUBBER BLANKET ( ) OTHER			VOLATAGE SOURCE: (x) STABLE	( ) UNSTABLE

TEST DATA				
AMBIENT TEMP:	RELATIVE HUMIDITY: n/a %	TEST EQUIPMENT: KV HI-POT	Ser # MDL/SER Mfg	CALIBRATION: MEGGER BY:

MEGGER TEST @ 1000 VOLTS @ 1 MINUTE IN MEGOHMS				NOTES:						
TEST	CABLE TO GROUND						A	B	C	NOTES:
Pre-Hypot	INFINITY						NOT APPLICABLE			
Post-Hypot	INFINITY									

STEP VOLATAGE TEST			ABSORPTION TEST		
VOLT KV	LEAKAGE CURRENT MICRO AMPS	TIME MIN.	LEAKAGE CURRENT @ ____ KV MICRO AMPS		
0.50		0.5			
1.00		1.0			
1.50		1.5			
2.00		2.0			
2.50		2.5			
2.60		3.0			
	na = nano amps				
	µa = micro amps				

NOTES:	TEST ENGINEER: (print) (sign)	DATE:
	WITNESS: (print) (sign)	DATE:
QA: (print) (sign)	QC: (print) (sign)	DATE:

SECTION 34 41 13

TRAFFIC SIGNALS

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for modifying existing traffic signals systems at the following locations.

Location 1: Capitol Expressway/Capitol Avenue

Location 2: Capitol Expressway/Story Road

Location 3: Capitol Expressway/Ocala Avenue

Location 4: Capitol Expressway/Cunningham Avenue

Location 5: Capitol Expressway/Tully Road

Location 6: Capitol Expressway/ Eastridge Mall

Location 7: Capitol Expressway/Quimby Road

Location 8: Capitol Avenue/Wilbur Avenue

1.02 REFERENCED STANDARDS

A. County of Santa Clara Standard Specifications, May 2000 and Amended January 2, 2011, and Standard Details, September, 1997 and Amended December 21, 2010.

1. Section 86 Santa Clara County Standard Specifications and Amendments to County Standard Details and Standard Specifications

2. Section E Santa Clara County Standard Details

B. State of California, Department of Transportation (Caltrans) Standard Plans and Specifications 2018:

1. Division X Electrical Work

C. California Manual on Uniform Traffic Control Devices (CA MUTCD)

1. Part 4 Highway Traffic Signals

D. City of San Jose Standard Specifications

1. Section 86 Signals, Lighting and Electrical Systems

2. City of San Jose Standard Details

1.03 SUBMITTALS

Submittals shall conform to the requirements of Section 86.01.04, “Submittals,” of the SCC County Standard Specifications.

1.04 EQUIPMENT LIST AND DRAWINGS

Equipment lists and drawings shall be prepared in accordance with the requirements of the applicable County Standard Specifications, County Standard Details, the Contract Plans and these special provisions. Attention is directed to Section 86.01.04 of the County Standard Specifications and the following:

A maintenance manual shall be furnished for all equipment, and vehicle detector sensor units, control units, and amplifiers. The maintenance manual and operation manual may be combined into one manual. The maintenance manual or combined maintenance and operation manual shall be submitted at the time the equipment is delivered for testing or, if ordered by the Project Inspector, prior to purchase. The maintenance manual shall include, but need not be limited to, the following items:

1. Specifications
2. Design characteristics
3. General operation theory
4. Function of all controls
5. Trouble shooting procedure (diagnostic routine)
6. Block circuit diagram
7. Geographical layout of components
8. Schematic diagrams
9. List of replaceable component parts with stock numbers

1.05 WARRANTIES, GUARANTEES, AND INSTRUCTION SHEETS

All Equipment furnished by the Contractor shall be guaranteed to the County, by the manufacturers, for a period of not less than one (1) year following the date of acceptance of the installation of such equipment unless specified otherwise. If any part (or parts) is found to be defective in materials or workmanship within the one year period and it is determined by the Engineer or by an authorized manufacturer’s representative that said part (or parts) cannot be repaired on the site, the manufacturer shall provide a replacement part (or parts) of equal kind and/or type during the repair period, and shall be responsible for the removal, handling, repair or replacement, and reinstallation of the part (or parts) until such time as the traffic signal and/or street lighting equipment is functioning as specified and as intended herein; the repair period shall be made upon notification.

The one (1) year guarantee on the repaired or replaced parts shall again commence with the date of acceptance by the County.

1.06 EQUIPMENT TESTING

Equipment shop and field testing shall conform to Section 86.02.13 "Testing" of the County Standard Specification.

1.07 MEASUREMENT AND PAYMENT

A. Measurement: SIGNAL AND LIGHTING shall be measured by the lump sum price by location as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for SIGNAL AND LIGTHING by location shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in traffic signals and lighting, including removal of existing spread foundations, salvage and deliver existing equipment, complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

A. Controller Cabinet

Controller Assembly for all county signals shall be contractor furnished and shall include the following items:

- Type "Stretch" P (P-68), NEMA TS-2 type II Cabinet
- 980-2 ATC Controller
- Cisco IE-4000-8GT8GP4G-E Fiber Switch, or approved equal

The Controller Assembly for Location 8 (Capitol Ave and Wilbur Ave) will be City of San Jose furnished. The controller assembly shall be available to the contractor for pick up at the Mabury Service Yard, 1404 Mabury Rd, San Jose, CA.

B. Service Cabinet

Service Cabinet shall be Type III-AF. Electrical service installation shall conform to Section 86.02.11 "Service," of the County Standard Specifications and the State Standard Specifications, County Standard Plans and these Technical Specifications.

C. Foundations

Foundations shall conform to Section 86.02.04 "Foundations" of the County Standard Specifications, Revised State Standard Plans number RSP ES-7B (for Type 1-B standard), and applicable Standard Plans (for signal/lighting standards) of the State Standard Plans and Project Plans. Foundations for the Type P signal controller cabinet, battery backup system cabinet, and Type III-AF service equipment enclosure shall conform to the details in the County Standard Details and Project Plans.

At Location 8 (Capitol Ave and Wilbur Ave) the contractor shall install the new City furnished controller assembly on the existing foundation.

When potential conflict with underground utilities is anticipated and with the approval of the Engineer, exploratory hole shall be dug. The cost of this work will be included in the prices for the various other items requiring the work.

D. Standards, Steel Pedestal and Posts

New standards shall be furnished and installed as shown on the Contract Plans.

Traffic signal and safety lighting standards shall be furnished and installed in conformance with these Special Provisions, Section 86.02.05 “Standards, Steel Pedestals and Posts” of the County Standard Specifications, County Standard Details Manual, the applicable State Standard Plans (for standards as specified on the project plans), and the following.

Traffic signal poles shall be set back from face of curb no less than 30 inches to face of standard or pole; and the base plate shall be installed parallel to the stop bar unless otherwise specified by the Engineer.

Contractor shall submit shop drawings for all signal and lighting standards and the Steel Certified Test Reports (e.g. Mill Test) for review by the Engineer. County will not accept any signal standard not meeting the requirements of this provision.

E. Conduit

New conduit shall be furnished and installed of the type and at locations shown on the Contract Plans to provide additional capacity where existing conduit runs are full, or to where no conduit currently exists. The primary color of conduit shall be orange. In instances where a four-conduit bundle is to be installed, then orange, gray, blue and black colored conduits shall be furnished and installed.
Conduit work shall be performed in accordance with the requirements of the applicable County Standard Specifications, County Standard Details, the Contract Plans and these Special Provisions. Attention is directed to Section 86.02.06 of the County Standard Specifications and the following.

Unless other specified, all conduit installed under this Contract shall be Schedule 80 PVC or HDPE. PVC conduit shall be manufactured in accordance with NEMA TC-2-1998 standards. HDPE conduit shall be manufactured in accordance with NEMA TC 7-2000 standards. Conduit under roadway pavement shall be a minimum of three (3) inch diameter unless where a four or three-conduit bundles is to be installed.

A four-conduit bundle will consists of 3 x 2 inch conduits and 1 x 3 inch conduit (for Detector Loop Cable) installed in the same bore or trench. A three-conduit bundle will consist of 3 x 2 inch conduits installed in the same bore or trench. Contractor, with the approval by the County, can substitute either 2 inch or 3 inch conduit for a larger size if percent fill for conduit as shown does not satisfy County’s requirement of 35% maximum.

Conduits shall be color coded as described by the following:

- Detector Loop Cable – BLACK Color
- Traffic Signal and Lighting – RED Color
- Video Camera and ITS Elements – ORANGE Color
- Empty – GRAY Color

The directional boring method shall be used for the installation of conduit except where short conduit runs are required and right-of-way is limited for setting up boring equipment, then open-trenching shall be permitted subject to approval by the County Engineer. When trenching in pavement is allowed, the conduit installation shall meet the trench in pavement requirements of Section 87-1.03B (6) "Conduit Installation by the Trenching-In-Pavement Method," of the State Standard Specifications.

In the event if the County deems the existing conduit as unusable, contractor shall replace the existing conduit with new conduit of like size. The replaced conduit shall be considered and paid for as new.

Conduit shall be installed at depths as specified in Section 86.02.06C "Installation" of the County Standard Specifications, except that conduits installed within the paved or unpaved median, shall be at a minimum depth of 36 inches below finished grades. Placement of conduit on top of roadway pavement within the paved median island will not be permitted unless so specified on the project plans or in these Special Provisions.

Where conduit is left empty or with no metallic conductors it shall have one (1) #8 AWG, THW stranded copper locating wire. The insulating jacket of the wire shall be green. Where bundles of multiple conduits are installed in the same bore or trench, the locating wire may be installed in only one conduit. It shall then be installed in one of the empty conduits.

Conduit shall be able to withstand 95% soil compaction without collapsing.

Conduit and condulets used to penetrate the base of a controller cabinet, and conduit used for external connections to new NEMA enclosures to be mounted on the side of existing controller cabinets, shall be galvanized rigid steel.

Contractor may elect, at his option and expense to install new conduit in lieu of installing new wiring in existing conduits. Any additional wiring or connections required shall also be at the Contractor's expense. Prior to exercising this option at any location the Contractor shall advise the Engineer in writing of his intent.

At locations of pull box, pole foundation, cabinet foundation, conduit ends shall be terminated as specified on the Project Plans and in Section 86.02.06C "Installation" of the County Standard Specifications.

F. Conduit Dividers

Conduit dividers shall be installed in new or existing conduit to receive new fiber optic cable as shown on plans.

Conduit dividers shall be Maxcell by TVC Communications or approved equal. Dividers shall be installed as follows:

- In existing, occupied conduits sized 2 inch or 3 inch, furnish and install a 2 inch one-cell divider.
- In new conduit sized 3 inch, furnish and install a 3 inch one-cell divider.

Dividers shall be installed according to the manufacturer's recommendations. At locations where the divider can be installed without damaging existing conductors, this specification does not require removal or reinstallation of existing conductors. In this case, use a fiberglass rodder to install

Maxcell if there is not an existing pull rope. A fiberglass blow tape may be used instead if approved by the Project Engineer. Under no circumstances shall a metal fish tape be used to install Maxcell in conduits with existing conductors. At other locations, installation shall conform to the requirements for conductor installation, as specified in Section 89.02.09B of the County Standard Specifications, except that slack will not be required in pull boxes and labeling shall be done through use of individually colored pull tapes or ropes in empty cells.

The Contractor shall be responsible for any damage to existing cable as a result of Contractor's operations. In addition, the Contractor is responsible for documenting and reconnecting existing cable and wiring as found, and ensuring that it is left fully functional after new cables are installed. The Contractor may elect to inspect and conduct tests of existing cable prior to removal, in the presence of the Project Engineer, to record the operational condition of existing wires. The Contractor will not be held responsible for any cable damage found, documented, and noted by the Project Engineer, as part of the pre-removal inspection and testing.

G. Pull Boxes

Pull boxes shall be No. 6 unless indicated otherwise on the Project Plans and shall conform to Section 86.02.07 "Pull Boxes," of the County Standard Specifications and County Standard Details Manual E/8. Pull box cover marking shall conform to Section 86.02.07B "Cover Marking," of the County Standard Specifications except that the identification shall be "COUNTY". Pull box cover shall be a locking type.

Pull box material and installation shall conform to the applicable County Standard Specifications, County Standard Details, except as amended by these Contract Documents. Attention is directed to Section 86.02.07 "Pull Boxes" of the County Standard Specifications and the requirements for stub modification shown in the Contract Documents, and described herein.

Pull boxes shall be located behind the curb or at the locations shown on the plans. Pull boxes shall not be installed in travel way unless specified otherwise, in which case pull boxes and lids shall be rated for H-20 traffic load application and approved by the Project Engineer.

Pull boxes shall be grouted at the bottom per details in the Contract Documents.

Where existing pull boxes are specified in the Contract Documents to be replaced with larger pull boxes, existing conduit stub-outs in these pull boxes shall be cut back to provide stub-ups of 1 inch minimum to 2 inch maximum in length. Ground bushings shall be installed on metallic conduits and end bells on PVC conduits. All conduit entries into pull boxes shall be 45° sweeps and shall conform to County Standard Specification 86.02.06C.

All N40 pull boxes shall be installed with a 12-inch extension.

Contractor shall clean all pull boxes (new and existing) entered for installation of conduit or wire of all dirt and debris. All pull box lids damaged by Contractor operations shall be replaced at his expense. The wiring in these pull boxes shall be neatly bundled, recoiled and reinstalled in the pull box.

All pull boxes shall have locking lids. All pull box lids shall be Fibrelyte, if available, or approved equal.

H. Conduits and Wiring

Conductors shall conform to Section 86.02.08 "Conductors and Cables," of the County Standard Specifications.

Splicing existing DLCs will not be allowed.

Wiring shall include all work as specified, including the furnishing all necessary materials, equipment and labor for:

- Removing existing conductors and cables specified for reuse;
- Cleaning of existing conduits;
- Installing, connecting, and splicing new and existing conductors and cables in conduits, pull boxes, terminal compartments, traffic and pedestrian signal facilities, lighting facilities, service cabinets, and controller cabinets;
- Labeling all conductors; and
- Bonding and grounding electrical facilities.

Where existing conductors and cables are specified to be reused on the project plans, Contractor shall exercise care in the removal of and protect the cables from damage. The reinstallation of these cables into the conduit shall be expedited.

All conductors in pull boxes and cabinets shall be tagged and labeled in accordance with the requirements per E/44 of the County Standard Details Manual for new installation or modification to existing wiring.

Various conductors and wiring are needed for connections including those to CCTV cameras, loop detectors, pedestrian sensors, bicycle detectors, service points and enclosures. The Contractor shall furnish and install the conductors and wiring indicated in the Contract plans.

Conductors and wiring work shall be performed in accordance with the requirements of the applicable County Standard Specifications, County Standard Details, the Contract Plans and these special provisions. Attention is directed to Section 86.02.08, "Conductors and Cables," Section 86.02.09 "Wiring," of the County Standard Specifications.

Fire preemption cable shall conform to the requirements of the existing Opticom preemption system.

CABLING FOR CCTV CAMERAS

CCTV Cable:
The Contractor shall furnish and install LAN-Trak OSP outside plant cable or approved equal. Cable shall have TIA/EIA-568-C.2 Category 5E or 6 electrical performance. Cables shall be designed for exposure to the elements. Jacket shall be black UV-resistant polyethylene, with craft-friendly semi-dry flooding material that cleans easily from the cable core.

Specifications:

Cable Type	4 Pair, 24 AWG, Duct/Aerial Lashed
Jacket Diameter	.261 inches
Weight	36 lbs/M
Min. Bend Radius	2.75 inches

Cable and power conductors shall be used at all intersections where new video cameras are being installed.

All CCTV cabling shall be tagged to indicate which camera it serves. The Contractor shall contact the Project Engineer for camera addressing. The Contractor shall test the cables for continuity prior to and after installation.

All cables shall be rated for outdoor, underground, dry and wet installation and be provided with appropriate strain relieved plug type connectors for connection to leads extending from the camera assembly.

The installation of the cabling may require that a hole be drilled into the camera supporting structure. Prior to drilling this hole the existing wiring inside the pole or mast arm shall be removed or protected such that it is not damage by the drilling operation. The edges of the drilled hole shall be smoothed. The Contractor shall install a watertight gland nut in this hole that securely holds the wiring.

The Contractor shall install the cable between the camera and the pole entrance such that it forms a drip loop to prevent water from flowing down the cable into the hole.

Camera video, power, and control cables shall be installed in the pole, conduit, and cabinets or side-mounted equipment enclosures. All cable runs shall be continuous and shall run without splices between the camera assembly and the cabinet. Cable ends shall be kept sealed at all times during installation using an approved cable end cap. Tape shall not be used to seal the cable end. The cable end shall remain sealed until connectors are installed. All terminations and cable connectors shall be installed per manufacturer specifications. The minimum bending radius of the cable, as established by the cable manufacturer, shall not be exceeded at any time. Where cables enter into an equipment cabinet, a minimum of two meters of cable slack shall be provided in the cabinet. Where cables enter into a side-mounted equipment enclosure, a minimum of two meters of cable slack shall be provided in the pull box nearest to the side-mounted equipment enclosure.

All cables shall be:

- installed without damaging the conductors or insulation;
- installed without kinks;
- installed with sufficient slack for equipment movement;
- have a watertight, strain relieved plug type connection to the camera housing.

Detailed requirements for installation of new wiring in conduits with existing wiring are stated elsewhere herein. These methods and provisions shall be followed by the Contractor.
The Contractor shall make all connections of this wiring to the camera assembly, the video transmission device and power.

I. Bonding and Grounding

Bonding and grounding shall conform to Section 86.02.10 “Bonding and Grounding,” of the County Standard Specifications.

J. Closed Circuit Television (CCTV) Camera System

The Contractor shall furnish and install CCTV items: camera, mounting hardware, lenses, cables, and. and any additional equipment required for a complete and operational CCTV assembly.

The CCTV assembly shall be installed such that the camera viewing coverage is optimized as directed by the Project Inspector.

MATERIALS

Fixed camera assemblies shall include the following components: camera, lens, pan/tilt unit, camera controller dome housing, surge suppression, mounting hardware, ground loop isolation transformer, and power supply. A description of the camera equipment is provided below.

Fixed Cameras:

Cameras shall be IXE32DN-PL Sarix EP Network Camera with EP network day/night feature and Pelco Enhance Suite or approved equal. At a minimum, camera shall have is a 2.1 megapixel (MPx) network camera with industry-leading image quality and high performance processing power. Camera shall install quickly and include automatic back focus control, built-in analytics, and other advanced features.

Camera shall include the Enhanced Suite of the Pelco Analytic Suites and ObjectVideo (OV) Analytic Suites. The Enhanced Suite shall be capable of running up to three behaviors at the same time.

Analysis Software shall include Object Counting that counts the number of objects that enter a defined zone or cross a tripwire.

The OV Event Counting Suite shall use advanced object calibration and additional features for schedules, parameters, and multiple rules. The suite shall include behaviors for tripwire counting, enters/exits counting, loiter counting, occupancy sensing, and dwell-time monitoring.

Lenses:

Contractor shall furnish and install 13M15-50 Megapixel lens with varifocal, 2.8-12.0 mm, f/1.4-5.7, 1/3-inch format, 3 megapixel, auto iris (direct drive) features.

Specifications:

MODEL	13M2.8·12
Type	Varifocal
Format Size	1/3-inch
Mount Type	CS
Focal Length	2.8-12.0 mm
Zoom Ratio	4.3X
f-number (iris fully opened)	1.4-2.7
Image Size	6 mm diameter
Flange focal Length	12.5mm
Minimum Object Distance	0.3 m

Iris	Auto
Field of View	
Wide	
Vertical	74°
Horizontal	100°
Diagonal	127°
Tele	
Vertical	18°
Horizontal	23°
Diagonal	29°
Focus	Manual
Zoom	Manual
Operating Temperature	14° to 122°F
Storage Temperature	-4° to 140°F
Relative Humidity	35% to 90%
Iris Drive Coil Resistance	190W ±l0%
Iris Damping Coil Resistance	500 W ±l0%
Maximum Iris Operating Current	23 mA at 4vDC
Unit Weight (approximate)	0.13 lb
Shipping Weight (approximate)	1 lb

Note: When power is turned off, the iris will close automatically.

Power Supply:

The Contractor shall furnish and install TF9000 or approved equal power supply. Power Supply shall include 120 VAC, 60 Hz input, one fused, single 24 VAC output, and provides 50 VA output.

Enclosure:

The Contractor shall furnish and install EH3512-2HD Enclosure or approved equal. Enclosure shall house a camera 10.00 inches long by 2.87 inches wide by 3.00 inches high and be rated for 24 VAC and 20W power consumption. Enclosure shall include a heater, defroster, and sun shroud.

Mounting Hardware:

The Contractor shall furnish and install EM1109 pipe/pole mount or mounting hardware specifically designed for mounting the camera/enclosure provided. Mounting shall be equipped with a manually adjustable swivel head and cable feed-through hole.

INSTALLATION

The Contractor shall install the CCTV assemblies at those locations as shown in the Contract Documents. The pole mounting adapter shall be electrically bonded to the camera pole. The camera assembly shall be electrically bonded to the pole mounting adapter. Refer to Section 111-29.14, “Conductors and Wiring”, for cable additional installation requirements.

The Contractor shall install and fully adjust the camera with the associated lens, power supplies, housings, and pan/tilt and dome units (if applicable), and furnish and install all necessary cabling, etc., to make the assembly completely operational.

The Contractor shall firmly attach the camera to the housing. The Contractor shall exercise care to tighten the camera mount within the torque limits specified by the camera manufacturer.

The Contractor shall properly terminate all of the electrical cables to the camera and firmly attach them.

The camera shall be mounted in the housing within 0.24 inches of the optical window. This distance is measured with the lens attached and adjusted to its maximum physical length.

The Contractor shall mount the camera in the housing such that the lens is centered in the optical window.

Positioning and Configuration of Fixed Camera Equipment

Cameras and other video sources where possible, shall use the electrical power supply 60 Hz signal for synchronization. After installation, the Contractor shall adjust the phase setting to synchronize all cameras, and other video sources where possible.

There shall be no image roll when different cameras are sequentially switched to the same monitor.

When cameras are initially installed, they shall be aimed to view one leg of the intersection at which they are installed. The intersection leg to be viewed shall be as designated by the Engineer. The initial aiming of cameras shall allow viewing of the stop line for approaching traffic and part of the intersection itself in the foreground, and the approaching and departing roadway (to the horizon if possible) in the background. The Contractor shall enable the Engineer to interactively view the camera image and choose the view for-the first camera installed, and thereafter shall use that experience to aim other cameras similarly.

After all cameras are installed and central equipment is operational, the Contractor shall arrange an interactive session with the Engineer to fine tune the aiming and other adjustments at cameras, including the stop points and presets for moveable cameras. This session shall enable the Engineer to observe the image at the control room while being in verbal communication with the Contractor at the camera. The means of verbal communication shall be provided by the Contractor. The Contractor shall make adjustments as directed by the Engineer. The Engineer will continue to observe the image while adjustments are made and will direct further adjustments as needed to achieve the desired view and picture quality. A representative of the Contractor shall accompany the Engineer in the control room during this procedure.

Camera aiming adjustments may involve rotation of the entire camera mounting around the supporting pole or arm and small longitudinal movements along the pole or arm within the limits of the attached cables, in addition to adjustments within the mounting hardware. Contractor shall ensure the camera lens and enclosure glass are left clean.

Testing

All equipment shall be tested at the camera locations and the TOC during both daytime and nighttime to verify proper operations and ensure picture quality. The testing shall be conducted in conformance with these Specifications.

The Contractor shall arrange to have a signal technician, qualified to work on the CCTV Camera System and employed by the CCTV Camera System manufacturer or his representative, present at time the equipment is turned on.

The video images shall meet the requirements of the National Television System Committee (NTSC) standard of one volt peak-to-peak, 75 Ohms signaling and the Electronic Industries Association (EIA) standard EIA RS_250C.

The Contractor shall successfully complete the Camera Cable Test and Local Operations Test as described below.

Camera Cable Test:

The Contractor shall perform the following Camera Cable Test. The Contractor shall furnish all equipment, appliances, and labor necessary to test the installed camera cable between the camera assembly and the cabinet. The Contractor shall perform the following tests before any connections are made:

1. Perform continuity test on the camera cable. Camera cable must not exhibit any discontinuities such as opens, shorts, crimps, or defects.

2. Perform continuity tests on the stranded conductors element of the camera cable 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 300 meters of conductor.

3. Measure the insulation resistance between the conductors and between each conductor, ground, and shielding using a meggar. The resistance must be “infinity”. All resistance testing is to be performed after final termination and cable installation, but prior to connection of any electronics or field devices.

4. Should any cable fail to meet these parameters, or should any testing reveal defects in the cable, the Contractor will replace the cable, then retest new cable as specified above.

5. Submit copies of the test results, including any unsuccessful and subsequently successful tests to “The Engineer” prior to any field operations testing.

Local Field Operations Test:

The Contractor shall perform the Local Field Operations Test at the CCTV field site, as follows. After all camera hardware, power supply, and connecting cabling has been installed, demonstrate the following:

1. Verify physical construction has been completed in accordance with the Contract Documents and specifications.

2. Inspect quality and tightness of ground and surge protector connections.

3. Check power supply voltages and output.

4. Connect devices to power source.

5. Verify the installation of specified cables and connections between camera, pan/tilt unit, camera control receiver, and video/data transmission equipment.

6. Set the camera control address.

7. Verify presence and quality of video image locally with laptop computer (assisted by County technician).

8. Test local operation of all CCTV equipment, by exercising the pan, tilt, zoom, focus, iris opening, and manual iris control selection and operation, low pressure alarm (if present), pre-set positioning, and power on/off functions while observing the video picture on a laptop computer and assisted by a County technician. The County will provide software to the Contractor for testing of the CCTV unit. The Contractor will furnish all other test equipment.

9. Demonstration of camera sensitivity at low light levels to meet the specified requirements.

10. Demonstration of pan/tilt speed and extent of movement to meet the specified requirements.

11. Measurements of video signal level at the communications interface.

12. Verify proper voltage of power supply.

13. Submit copies of the test results, including any unsuccessful and subsequently successful tests to the Project Engineer prior to any field operations testing.

K. Pan Tilt Zoom (PTZ) Camera System

GENERAL

The Contractor shall furnish and install Pan Tilt Zoom (PTZ) items: camera, mounting hardware, lenses, cables, and. and any additional equipment required for a complete and operational PTZ assembly.

MATERIAL

PTZ camera assemblies shall include the following components: camera, lens, pan/tilt unit, camera controller dome housing, surge suppression, mounting hardware, ground loop isolation transformer, and power supply. A description of the camera equipment is provided below.

PTZ Camera Details

- The new camera shall be color, full HD with video quality of 1080 pixels.
- The camera shall have an optical zoom at a minimum of 18x, and a digital zoom of a minimum of 4x.

- The video compression shall be H.264 standard, multi-streaming.
- The camera shall have the ability to be controlled remotely from the County's traffic management center.
- The camera shall include power over Ethernet injector for single cable installation.
- Camera shall be compatible with the Pelco Endura Video Management System.

Camera Mounting Details

The PTZ camera shall be mounted to the side of the pole shown on the plans, using manufacturer recommended bracket. The mount shall have the following specifications.

- The mount shall fit the poles between 3 to 15 inches in diameter.
- Mount shall work with any PELCO branded PTZ cameras.
- Mount shall be powder coated and made out of steel.

L. Layer 2 Ethernet Switch

GENERAL

The Contractor shall furnish and install Layer 2 Ethernet Switch. The Switch shall be Cisco IE-3000-8TC-E (Layer 2) or approved equal.

Switch

Cisco IE-3000-8TC-E shall include the following items:

- 100Mbps Single Mode Rugged SFP (2 fibers per port)
- Field hardened power transformer, PWR-IE3000-AC series.

The Switch shall be environmentally hardened and intended for industrial applications and shall meet or exceed the NEMA TS2 2003 environmental requirements. The switch shall meet, at a minimum, the following requirements:

- A minimum of two (2) 100BASE-FX ports (transmit and receive) capable of transmitting Ethernet data at 100 Mb/s over singlemode fiber, full duplex (SFP ports)
- A minimum of six (6) autosensing 100BASE-TX / 10BASE-T RJ45 ports capable of transmitting Ethernet data at 10 or 100 Mb/s, full duplex.
- Switch shall be capable of operating using an input voltage of 120VAC at 60Hz with a maximum power consumption of 20 watts, or shall come equipped with power supplies capable of doing so.
- Switch ports shall comply with the following standards:
    - IEEE 802.3 10Base-T
    - IEEE 802.3u 100Base-TX
    - IEEE 802.3u 100Base-FX
    - IEEE 802.3ab 1000Base-T

- IEEE 802.3z 1000Base-SX and 1000Base-LX
- IEEE 802.1P priority queuing
- IEEE 802.3X flow control

- Wire speed switching on all ports simultaneously, non-blocking
- IEEE 802.1Q VLAN Tagging 4 port trunking groups with up to 2~4 ports per group with support for 256 VLANS
- Meets Bellcore GR-63-CORE vibration and shock specifications for NEBS Level III compliance (optional)
- Operating temperature = -34 to +74 degrees Celsius
- Relative humidity = 10% - 90%, non-condensing
- UL listed (UL1950), cUL, CE
- Emissions meet FCC Part 15, Class A
- Minimum MTBF of 8 years (Bellcore Method)
- Packet Filtering and Port Security Destination MAC
- MAC address learning with a minimum of 1028 MAC addresses and 1028 static MAC addresses
- IEEE 802.1p QoS Classification based on: Port based priority VLAN Priority field in VLAN tagged frame DS/TOS field in IP packet UDP/TCP logical ports
- IEEE 802.1w Rapid Spanning Tree Algorithm
- IP Multicast Filtering through IGMP Snooping
- Support Telnet, SNMP v1 and v2, RMON, Web Browser, Port Mirroring (RFC 1757, TFTP, FTP and CLI management tools
- MIB statistics counters for all ports
- Management and configuration shall be able to be performed through an integrated web interface
- Support remote reset and remote management
- Support remote turn on/off of 10/100 Base-T ports
- The switch shall have a minimum MTBF of 60,000 hours. The MTBF shall be calculated in accordance with the methods described in Mil-Std HDBK 217F for a temperature of 55ºC for naval sheltered.

M. Traffic Signal Faces and Fittings

The Contractor shall furnish and install signal heads and hardware as specified in these Project Plans and in section 86.04 “Traffic Signal Faces and Fittings,” of the County Standard Specifications and the following:

- All signal heads shall be installed with aluminum backplates and visors, all with black homogeneous color.

- All signal head shall have LED indications manufactured by GE Ecolux, Leotek or approved equal.

Upon installation, contractor shall temporarily mask all signal indication with an approved tape until the signal system is turned on for operation, at which time Contractor shall remove it.

New vehicle signal faces and signal heads shall be installed as shown in the Contract Documents.

The work in this Section shall be performed in accordance with the requirements of the applicable County Standard Specifications, County Standard Details and the Contract Documents.

Signal Head Mounting Hardware

The Contractor shall furnish and install signal mounting hardware.

Signal head mounting hardware shall have adequate length on their component to accommodate the backplates and permit adjustment of the signal head for proper alignment.

Mounting hardware for pole top and side installation, and mastarm tenon installation shall conform to Revised State Standard Plans RSP ES-4A and RSP ES-4E.

N. Pedestrian Signals

Pedestrian signal head shall be furnished and installed as specified on the Project Plans and in Section 86.02.01 “Mobility-Impaired Access Provisions,” and Section 86.04.05B “LED Countdown Pedestrian Signal Module,” of the County Standard Specifications.

Where new traffic signal standards are required in the Contract Documents, pedestrian signal heads shall be furnished with LED type. LED pedestrian signal heads shall have a Portland orange “UPRAISED HAND” and lunar white “WALKING PERSON” capable of fitting into the standard Type A signal housing and replacing incandescent lamps, meeting the requirements of GE’s Ecolux or approved equal.

O. Pedestrian Push Buttons

New pedestrian push buttons shall conform to the requirements of section 86.04.04B and 86.04.04C of the County Standard Specifications.

Pedestrian push buttons shall be Campbell Guardian APS 4-wire type, or approved equal.

P. Pedestrian Sensors

Contractor shall furnish and install pedestrian motion sensors for crosswalk occupancy detection. Sensors shall be MS SEDCO SmartWalk XM or approved equal and meet the following specifications:

Operating Frequency: 24.125 gHz

Detection Method: Microprocessor analyzed Doppler microwave

Detection Pattern: Adjustable with cover off

Detection Angle: Adjustable

Detection Mode: Selectable: approach only, depart-only or bi-directional motion

Call Extension Time: 0.1 to 5 seconds

Power Requirements: 12 to 24 V AC or DC + or – 10%

Power Consumption: 1W maximum

Relay Output: Form C, rated at 1 Amp @ 24V DC (N.O. and N.C.)

Output Power: 5mW typical, 2mW minimum

Relay Contact Ratings: 0.5A:50V AC-1A:24V DC

Operating Temperature: -22 degrees F to 158 degrees F

Physical Dimensions: 4”W x 4”H x 7”L

Enclosure: Powder coated aluminum

Weight: 4 lbs.

Two pedestrian motion sensors shall be installed per crosswalk (one at both ends). Contractor shall follow manufacturer’s installation instructions to complete installation.

Pedestrian Sensors and cabling shall be installed per County standard plan E/54, manufacturer’s recommendation, and as directed by the Engineer.

Q. Detector Loops

GENERAL

Loop Detection System shall conform to Section 86.05, “Detectors” of the County Standard Specifications, County Standard Details Manual, Section 86-5, “Detectors” of the State Standard Specifications, the Contract Plans, and these Special Provisions.

Contractor shall remove and replace any detector loops and/or detector handholes shown on the plans to remain that are removed or damaged by pavement repair operations. For areas that are to be excavated, contractor shall notify USA and County Traffic Electrical and Operations Department to field ID location of existing loop locations prior to any excavation.

Any detector handholes within resurfacing area shall be protected and remain exposed after all pavement repair operations are complete.

Contractor shall furnish and install new detector loops and sensor units as shown in the Contract Documents to supplement stop bar detection and for system loops.

Detector work shall be performed in accordance with the requirements of the applicable CCS, County Standard Details, and the Contract Documents. Attention is directed to County Standard Specification 86.05.04 and County Standard Detail E5/A.

The Engineer shall approve new traffic detector loops layout and home runs prior installation.

The Contractor shall test all individual loops and all DLC prior to and after splicing in the presence of the project Inspector. The Contractor shall test loop sensitivity with either an approved lightweight motorcycle or an Engineer-approved wind wand.

New detector sensor units shall conform to the requirements of Section 86.05.01 of the County Standard Specifications except units shall be 4-channel units. At all locations, new one-slot detector units shall be installed in existing detector racks and shall be fully compatible with existing equipment. Where racks do not contain adequate slots for the new units, existing 2-channel units shall be replaced with new 4-channel units.

At locations where the plans show reconnecting existing advance loops to new lead-in cables, the Contractor shall field check existing advance loop wiring and notify the Project Engineer of any loops with shared loop wires. The Project Engineer will make a determination on any required replacement.

INDUCTIVE LOOPS

All new detector loops shall be Type B per Caltrans Revised Standard Plan RSP ES-5B except for loops closest to the stop bar. All new stop bar loops shall be Caltrans type D per the Caltrans Revised Standard Plan RSP ES-5B.

The installation of inductive loops shall conform to Section 86.05.04 “Detector Loop Installation” the County Standard Specifications and Standard Detail E/5A of the County Standard Details Manual.

Residue resulting from slot cutting operations shall not be permitted to flow across shoulders or lanes opened to public traffic. It shall be contained by an approved method during the slot cutting operation and removed immediately upon completion of the cutting operations. Discharge of the residue into the storm drainage system is not permitted.

Detector loops shall be Type 2. Detector handholes shall be Type A. Attention is directed to County Standard Specification 86.05.04 and County Standard Detail E5/A.

The Engineer shall approve new traffic and bike detector loops layout and home runs prior to installation.

Where pavement markings for stop bar/crosswalk and lane stripes are relocated or obliterated, County Survey will identify and mark the center points of the inductive loops and centerlines of the stop bar and lane/shoulder stripes. County Signal Inspector will verify and approve the marked locations of these facilities prior to loop cutting of pavement by Contractor.

The Contractor shall test all individual loops prior to and after splicing in the presence of the County Inspector. The Contractor shall test loop sensitivity with either an approved lightweight motorcycle or an Engineer-approved wind wand.

Any existing defective loop replacement as approved by the Engineer shall be done as extra work. Replacement of loop performed by the Contractor without meeting the requirements as specified in this section or due to damage by the Contractor’s operation shall be at Contractor’s expense.

INDUCTIVE BICYCLE LOOPS

All inductive bicycle loops shall be modified Caltrans Type D (3’ x 3’) loops.

The Engineer shall approve new bicycle detector loop layouts and home runs prior to installation. The Contractor shall work with the County Signal Inspector to verify the locations of existing vehicle loops and homeruns. This will help to prevent damage to existing loops when sawcutting for new bicycle loops is taking place.

Residue resulting from slot cutting operations shall not be permitted to flow across shoulders or lanes opened to public traffic. It shall be contained by an approved method during the slot cutting operation and removed immediately upon completion of the cutting operations. Discharge of the residue into the storm drainage system is not permitted.

New detector cards shall conform to the requirements of Section 86.05.01 of the County Standard Specifications except they shall be 4-channel units.

DETECTOR HANDHOLES

Detector handholes shall conform to Standard Detail E/5A of the County Standard Details Manual and shall be located as indicated on the project plans.

DETECTOR CABLE

Detector loop conductors and lead-in cables shall conform to Section 86.05.03 "Detector Loop Materials" of the County Standard Specifications and the following:

- Detector loop conductors shall have the required information per NEC, Article 310-11 marked on the surface of the conductor insulating jacket. The identification on the tubing is optional.

- Detector lead-in cable shall be labeled and terminated inside the controller cabinet.

Where existing loops require new DLC, the Contractor shall test all existing loops individually and all DLCs prior to disconnecting in the presence of the Project Inspector with method approved by the Project Engineer. The Contractor shall test loop sensitivity with either an approved lightweight motorcycle or an Engineer-approved wind wand. If existing loops and/or DLCs are found defective, the Project Engineer shall be notified for a corrective action. Existing DLC will be used where it tests as serviceable.

If no additional DLC is required in existing conduit runs, the Contractor shall test the existing DLC in the presence of the Project Inspector. If the test shows the DLC to be acceptable, they must be re-used.

All new DLCs shall be Type "B" and loop wires shall be Type 2.

R. Lighting

Lighting shall conform to the requirement of the County of Santa Clara Standard Specifications Section 86.06, Section 86-6.02 of the Revised State Standard Specifications, and the following.

LUMINAIRES

The Contractor shall furnish and install (at all locations as indicated on the plans) LED Luminaires as depicted on the Caltrans Prequalified Product List, available on Caltrans website. Luminaires must be Light Emitting Diode (LED) and must be equal to 135W or as approved by the County Engineer.

All items described within the specifications must be new, unused, and of the manufacturer's latest design and model unless otherwise specified. All Standard Equipment must be provided. All necessary parts not mentioned, but needed for operation of the items specified must be supplied.

The fixture shall be slim with a low profile design that minimizes wind load requirements. Fixture is constructed from rugged extruded aluminum and cast aluminum components. LED drivers are mounted in the cast aluminum housing which is suitable for wet listed operation (per UL 1508 requirements). Finish includes an E-coat epoxy primer with an ultra-durable powder topcoat providing excellent resistance to corrosion and ultraviolet degradation and abrasion.

1. Luminaire Efficiency – allow for thermal and optical losses - efficiency should be determined on a delivered lumens per watt basis for comparison at each luminaire drive current required.

   Initial delivered lumens per watt minimums required with independent testing lab verification:

   60 Lumens per watt (L/W) at 350mA drive current

   50 Lumens per watt (L/W) at 525mA drive current

   45 Lumens per watt (L/W) at 700mA drive current

2. Depreciation

   - Average Delivered Lumens – Average delivered lumens over 50,000 hours of operation should be a minimum of 95% of initial delivered lumens.

   - LED's in the luminaire shall be rated for "life" in hours as defined by IESNA standards.

   - Average delivered lumens for 350 mA drive current shall be 70% of initial delivered lumens after > 150,000 hours of operation at 15 C ambient

   - Average delivered lumens for 525 mA drive current shall be 70% of initial delivered lumens after 117,000 hours of operation at 15 C ambient (does not apply to 40, 50 and 60 LED product)

   - Average delivered lumens for 700 mA drive current shall be 70% of initial delivered lumens after 65,000 hours of operation at 15 C ambient (does not apply to 50 and 60 LED product)

3. Light Distribution – Specify light Distribution required and IESNA luminaire Classification (LCS). Fixture should have FVH and BVH values of equal to or less than 0.5%, and UP of 0%. The LCS values are intended to replace previous "Full Cutoff" designation which is no longer printed on test reports per IES TM-15-07 standard. Luminaire should have independent photometric test reports and be Dark sky compliant.

4. Maximum System wattage (including driver loss) –

   LED wattage only not accepted.

   <u>Provide calculation of delivered lumens/total wattage with bid.</u>

   If LED lumens/watt increase between the time of specification and the time product of ordering you will either get more light for the same energy or be able to reduce the wattage to obtain the same delivered lumens.

5. Color Temperature and CRI – 6000K +/- 500 color temp, 75 CRI.

6. Warranty – 5years on the LEDs, 5 years on the driver, 10 years on the paint finish of the fixture. (Pole warranty listed separately)

7. Electrical Safety – wet listed in the US and Canada, UL, ROHS and EMI, Class 1 rated luminaire

8. Driver Specifications

    A. Electronic
    B. Voltage range (120 – 277V) +/- 10%, (347-480V) +/-10% optional
    C. Current .350 Adc (+/- 5%), .525 Adc (+/-5%), .700 Adc (+/-5%)
    D. Frequency 50/60 Hz
    E. Power Factor >90% at full load
    F. THD < 20% at full load
    G. Load Regulation: +/- 1% from no load to full load
    H. Output ripple < 10%
    I. Output should be isolated
    J. Case temperature: rated for -40 through +80 C
    K. Fully encased and potted
    L. Overheat protection, self-limited short circuit protection and overload protected
    M. Primary Fused
    N. Life rating not less than 100,000 hours

9. Mechanical / Other

    A. Tool-less entry

    B. Utilizes terminal block for power input suitable for #6 AWG wire

    C. Designed to mount on 1.25” IP and / or 2” IP horizontal tenon and is adjustable +/-5 degrees to allow for fixture leveling

    D. Bubble leveling

10. Factory installed options

    A. Button Photocell

    B. IP66 Rating

    C. Fuse

    D. NEMA photo control receptacle

    E. Backlight Cut-Off

11. Provide the Following information with the bid Proposal:

    A. Literature

    B. Detailed Manufacturer's Specifications

    C. Test Reports

S. Battery Backup System

Existing battery backup cabinet shall be relocated as shown on the plans or as directed by the Engineer.

PART 3 – EXECUTION

3.01 MAINTANINING EXISTING AND TEMPORARY ELECTRICAL SYSTEMS AND TRAFFIC COMMUNICATIONS SYSTEMS

Maintaining existing and temporary electrical systems and traffic communications systems shall be performed in accordance with the requirements of the applicable County Standard Specifications, County Standard Details, the Contract Plans and these Special Provisions.

Contractor shall ensure that the existing and temporary traffic signal and/or communications facilities are in operational condition until the transfer of existing system to new system.

Contractor shall take precaution not to damage any existing traffic signal and communications facilities that are to remain in place and operational during and post construction. Damage to the signal and communications facilities due to Contractor's operation shall be repaired or replaced at the Contractor's cost in accordance with Section 86.01.06 "Maintaining Existing and/or Temporary Electrical Systems and Traffic Communications Systems" Of the County Standard Specifications.

Traffic signal system shutdowns shall be limited to periods allowed for lane closures listed or specified in Section 01 55 24, "Traffic Control" of these Special Provisions unless otherwise approved by the Engineer. Signal operations including the signal detection system must remain in operational during construction and an approved detection method must be provided if the existing detection system becomes non-operational as a whole or in part due to construction activities.

3.02 SYSTEM TESTING

To verify complete system operations the Contractor shall perform a communications subsystem test and system communications test.

Communications Subsystem Test

The communications subsystem test will verify the intersection to hub communications. This test shall not be conducted until the following conditions are met:

- All field CCTV cameras have been installed and passed their local operations test.
- All fiber optic cable has been installed, spliced, terminated and tested.

- All intersection to hub communications equipment has been installed and all terminations have been made.

The Contractor shall conduct, pass, and document a test to demonstrate the functionality of the CCTV camera sites, and master controllers from their respective communications hubs. The test shall be performed at the communication hub, and shall include the following elements. The test shall be conducted on the output of the fiber switch located in the TOC.

1. Operation of all pan/tilt camera assemblies, i.e., exercising the pan, tilt, zoom, focus, and iris functions, while observing the video picture monitor.

2. Verification of acceptable quality video images, and that video images output from the intersection fiber switch to Hub fiber switch conform to NTSC standards. For the fixed cameras, the test shall be conducted with all cameras at the intersection connected to the fiber switch at the intersection and transmitting video images to the Hub fiber switch. For locations that have master signal controllers, the master controller shall also be connected to the fiber switch at the intersection and two-way data shall be transmitted between the communication hub and the master traffic signal controller during the test.

3. Verification of valid data communications between the communication hub and the master controller. In addition, by using a laptop computer, the Contractor shall poll the master controller. This test shall be conducted while all fixed cameras at the intersection are also connected to the fiber switch at the intersection and transmitting video images. Polling of the master controller shall be conducted for at least 15 minutes with 99.9% valid polls required for acceptance.

The Contractor shall notify the County at least 48 hours prior to conducting the subsystem test. The Contractor shall document results of all tests on forms to be developed by the Contractor. The documentation shall specify the camera or controller tested, the results of the test and any corrective action that was necessary.

Communications System Test

The system communications test will verify the complete system communications from the TOC, through the communications hubs to the field devices. This test shall not be conducted until:

- All field CCTV and PTZ cameras have been installed and passed their local operations test

- All fiber optic cable has been installed, spliced, terminated and tested

- All intersection to hub communications equipment has been installed and all terminations have been made.

- All communications subsystem tests have been successfully completed.

The Contractor shall conduct, pass, and document a test to demonstrate the functionality of the CCTV camera sites, and master controllers from the TOC. All field equipment shall be connected to the communications network and transmitting video/data during the test. The test shall be performed at the TOC, and shall include the following elements.

1. Operation of all pan/tilt camera assemblies, i.e., exercising the pan, tilt, zoom, focus, and iris functions, while observing the video picture a monitor. The test shall verify that all commands are received and executed in real-time with no delay that will impact system operations.

2. Verification of acceptable quality video images, and that video images output from the fiber switch at the TOC conform to NTSC standards.

3. Verification of valid data communications between the communication hub and the master controller. In addition, by using a laptop computer, the Contractor shall poll and upload/download data to the master controller. Polling of the master controller or other acceptable method approved by the Engineer shall be conducted for at least 15 minutes with 99.9% valid polls required for acceptance.

The Contractor shall furnish all equipment necessary to conduct the communications subsystem test. The County will provide diagnostic programs for communicating to the master controllers and the pan/tilt CCTV cameras.

The Contractor shall notify the County at least 48 hours prior to conducting the subsystem test. The Contractor shall document results of all tests on forms to be developed by the Contractor. The documentation shall specify the camera or controller tested, the results of the test and any corrective action that was necessary.

3.03 RELOCATE EXISTING ELECTRICAL AND SIGNAL EQUIPMENT

Contractor shall relocate existing battery backup cabinets and other equipment shown on the project plans. Contractor shall furnish new cables for the relocated equipment from new equipment field location to the final terminal location in the controller cabinets.

Contractor shall take precaution measure to protect relocated equipment. Damaged equipment that results from the Contractor's negligence shall be replaced at Contractor's cost.

3.04 ABANDONING, REMOVING, REINSTALLING AND/OR SALVAGING ELECTRICAL EQUIPMENT

Work pertaining to this section shall conform to Section 86.07 "Removing, Reinstalling or Salvaging Signal/Electrical Equipment and Facilities" of the County Standard Specifications as amended by the following:

- Equipment specified for removal and reuse shall be maintained and stored by the Contractor. Any damage to the equipment shall be repaired or replaced by the Contractor at no additional cost to the County.

The Contractor shall deliver the Salvaged materials to the following locations for storage. Contractor shall notify TOC 48 hours in advance of the delivery date.

Santa Clara County TOC

1505 Schallenberger Road

San Jose, CA 95131

3.05 TEMPORARY TRAFFIC SIGNAL SYTEM

Temporary signal systems shall conform to the provisions of Section 12-3.33, ”Temporary Signal Systems,” and Section 87-20, “Temporary Electrical Systems’” of Caltrans Standard Specifications.

Temporary signal systems shall operate on a continuous 24-hour basis, unless traffic is controlled by flaggers.

Temporary signal system shall include temporary wireless interconnection and communications at each intersection. Temporary CCTV cameras shall provide real time video to the County Traffic Operations Center.

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SECTION 34 42 00

GENERAL RAILWAY SIGNAL REQUIREMENTS

PART 1 – GENERAL

1.01 SUMMARY

A. Scope of Signal Systems Work

This section describes the general requirements for the Contractor to design, manufacture, install, and test a complete and functioning train signal system. The Contract Drawings provide the general configuration of the completed signal system. The Contract Drawings also provide typical circuits, typical changes to existing circuits, and typical vital processor logic required to complete the design. The Contractor shall provide a complete detailed design, meeting the functional requirements as defined in the Contract Documents. The design shall also include staging and temporary work necessary to maintain full operations of the train signal system during the entire construction period.

B. VTA's Existing Light Rail System:

1. Alum Rock station is the southern terminus of the VTA Orange Line (Mountain View to Alum Rock line). It is a station with a diamond crossover providing access to the two tracks in the station. The existing system currently ends at the platform tracks that extend through the Wilbur Road crossing. There are two existing at-grade roadway crossings protected by "bar" signals at Alum Rock station: the Florence Avenue (between southbound home signals and diamond crossover) and Wilbur Avenue (next to south end of platform). Interlocking signals and switches are provided for all train movements.

2. Trains are normally one-, two-, or three-cars, and are operated by train operators. Their movement is governed by wayside signals and rules for line-of-sight operation. Routing at interlockings is, in normal operation, performed automatically in the field by train route requests, via train-to-wayside communications equipment, to the wayside Signal System.

3. Power for the trains is provided by the Traction Electrification System. Power is received from local electric utility at TES substations and then distributed in the form of (nominally) 800 Vdc power via the Overhead Catenary System.

4. The Younger Maintenance Facility serves as the LRT system's yard and maintenance facility, and houses the Operations Control Center (OCC) and central Equipment Room.

5. Supervision of Light Rail operations, using voice radio, telephone, and an existing central control system, is performed by Control Supervisors at the OCC.

C. Signal System Modifications:

1. General

The new line will consist of 3 miles of double track from the existing Alum Rock station south to the new end-of-line at Eastridge station. There will be two (2) new stations as part of the project, one at the intersection of Story road, and the other at the end-of-line at Eastridge Transit Center. The alignment includes an elevated structure that begins north of Capitol Avenue, just south of Wilbur Avenue, and extends approximately 2.5 miles south generally in the center of the median of Capitol Expressway, crossing over roadway crossings at Story Road, Ocala Avenue, Cunningham Avenue, and Tully Road. Once the guideway clears Tully, it descends to grade at Eastridge station. The interlocking at Eastridge, with power switches, will be used to turn back revenue trains.

2. Headway and Block design

The signal system will be designed to support a 3-minute operating headway assuming a nominal 20-second dwell time at stations and maximum 3 car train lengths. Maximum train speeds will be 55 MPH, with the exceptions of several curves which will allow for 40 and 50 MPH speeds. ABS signals will maintain a minimum one-block separation between trains traveling at Maximum Authorized Speed (MAS). Interlocking signals along with ABS signals will provide safe braking distances at MAS as shown on the Route and Aspect plans. Bi-directional signaling will be provided for the project limits.

3. Alum Rock interlocking to Story station shall be as shown on the Contract drawings and shall include but not be limited to the following;

a) There will be no track alignment changes at Alum Rock station.

b) Home signals and power switch machines will remain. Aspects for all home signals will not be changed.

c) Existing audio frequency track circuits within interlocking limits (C122T and C123T) shall be replaced with new PSO-4000 track circuits. New cable shall be installed through existing conduits for this purpose.

d) Existing impedance bonds and insulated joints at 966+29 shall be retired on both tracks. New insulated joints, impedance bonds and southbound ABS signals C130 and C132 shall be installed at 968+75. These ABS signals will allow trains to proceed south to Story station. The distance between these new signals and the Wilbur Avenue intersection will prevent blocking of this intersection when train is standing at these signals. Existing audio frequency track circuits (C127T and C129T) shall be retired and new Electrocode type DC coded track circuits shall be installed between northbound home signals (C123 and C125) at Alum Rock station and new ABS signals (C130 and C132). Equipment for these signals and track circuits will be mounted in new signal case SC968. Vital processor ElectroLogIXS or approved equivalent shall be installed in this signal case as well to control these ABS signals and adjacent coded track circuits. New coded track circuits will be added heading south from signal case on the extension until southbound interlocking signals at Eastridge, except platform track circuits at Story station; they shall be PSO-4000 type track circuits.

e) Existing VHLC processor in Alum Rock Signal House will be replaced with new ElectroLogIXS processor in this house. Existing VHLC application software will be converted into new ElectroLogIXS format and modified according to the required changes for Alum Rock. Contractor shall provide required wiring changes for connections to new ElectroLogIXS modules and communication network system. Existing LCP panel will remain, with required modifications.

g) New Train to Wayside Control (TWC) detection loops will be placed at 975+84 for activation northbound "bar" signal at Wilbur Avenue intersection. They shall be wired directly to the local traffic controller. These loops are the part of a Traffic Signal Design and must be considered in those specifications and drawings.

4. Story station to Eastridge interlocking shall be as shown on the Contract drawings and shall include but not be limited to the following;

   a) Story station is a new station on an aerial structure with a platform between tracks. Platform tracks C141FT and C132BT will be PSO-4000 track circuits or approved equal.

   b) Each platform track will be provided with two (2) ABS signals – for leaving the station in both directions. All signals provided in this project will be LED color signals driven directly by the Vital logic controller via DC Lamp Driver PCB.

   c) Signal/Communication house will be provided north of the platform to accommodate required signaling equipment at Story station.

   d) Vital processor ElectroLogIXS or approved equivalent will be installed in this house.

   e) This processor will have serial communication with vital processors on adjacent interlockings if needed and with Operations Control Center (OCC).

   f) There are two (2) coded track circuits on each track between Alum Rock interlocking and Story station, and four (4) coded track circuits on each track between Story station and Eastridge interlocking. Equipment for these coded track circuits will be accommodated in signal cases located next to insulated joints for these cut sections. There will be 3 signal cases between Story station and Eastridge interlocking. Signal cases will be fed from the signal houses or substations as shown on the drawings via direct underground cabling.

5. Eastridge interlocking shall be as shown on the Contract drawings and shall include but not be limited to the following;

   a) The Eastridge Interlocking will provide turn back operation for the end of the line. Eastridge Station area will have a center platform located at Eastridge station, a double crossover interlocking north of the Eastridge station and a pocket track interlocking located south of the platform. Eastridge station area shall be equipped with signals, power switch machines, TWC loops and track circuits.

   b) OS track circuits within interlocking limits will be PSO-4000 or approved equivalent.

   c) Un-tuned impedance bonds will be used to provide low resistance to DC traction return currents while maintaining a high impedance for signaling frequencies.

d) Route request TWC loops will be placed at all home signals. These loops will have the capability of cancelling a cleared route and requesting a new route.

e) Switch machines will be mainline type Alstom Model 5F or equivalent. All switches will be powered and will be interlocked to prevent unsafe or opposing routes and to prevent the movement of switches with a route aligned or with a train in the interlocking.

f) Pedestrian crossings on a southbound track will be provided for entering/leaving the platform. These pedestrian crossings will be equipped with flashers and pedestrian gates.

g) ABS will end at the south end of the pocket track interlocking signals.

h) Red disks will be placed to limit train movement in the pocket/tail tracks area for turnback operations near bumper posts.

i) Two vital processors ElectroLogIXS or approved equivalent will be installed at Eastridge Signal house: for double crossover interlocking and for pocket track interlocking accordingly.

6. Operations Control Center (OCC) shall be as shown on the Contract drawings and shall include but not be limited to the following;

a) OCC will have full control of all possible routes at the interlockings.

b) Standard alarms and indicators for the interlockings will be sent back to OCC via the communications backbone.

c) All track circuit indications on the line will report back to the station locations for transmission back to OCC providing continuous train tracking.

d) Signal aspects, light out alarms, TWC information, etc. will report back to OCC via the stations' communication systems.

7. Cross bonds shall be as shown on the Contract drawings and shall include but not be limited to the following;

a) The design requires specific cross bonds no more than 5900 feet apart for double rail track circuits with impedance bonds.

b) The design requirements paragraph 8.4.2.4 states "Wherever cross bonds are required at both ends of the same track circuit, no adjacent or parallel track circuit shall employ the same code rate for any vital aspect, including occupancy." Due to the lack of available code rates, it appears that this is impossible to implement the cross bond with only one track circuit in between cross bonds; therefore; two (2) track circuits minimum will be placed between cross bonds.

c) The distance between Substations 28 and 33 is approximately 7000 feet requiring one cross bond between. The proposed cross bond has been located at the stationing 1011+20. A cut section between the cross bond location and substation 33 has been added to provide the minimum 2 track circuits between cross bonds.

d) The distance between Substations 33 and 34 is approximately 4300 feet, therefore a cross bond will not be necessary between them.

1.02 REFERENCED STANDARDS

A. The following parts of the Code of Federal Regulations, Title 49, Transportation, shall apply:

1. Part 212 State Safety Participation Regulations.
2. Part 214 Railroad Workplace Safety.
3. Part 219 Control of Alcohol and Drug Use.
4. Part 218 Railroad Operating Practices.
5. Part 220 Railroad Communications.
6. Part 228 Hours of Service of Railroad Employees.
7. Part 234 Grade Crossing Signal System Safety.
8. Part 235 Instructions Governing Application for Approval of a Discontinuance or Material Modification of a Signal System or Relief from the Requirements of Part 236.
9. Part 236 Rules, Standards, and Instructions for Railroad Signal System.

B. In addition, the Contractor shall be responsible for adherence to all of the above rules and reporting requirements, including those regulations which require preemployment drug testing and random drug testing of employees engaged in the installation and testing of signal facilities, and the reporting and tracking of employees injured in the performance of work on a railroad.

1.03 SIGNAL SYSTEM MATERIAL

A. The Contractor-Furnished Equipment: Equipment provided under this Contract shall include, but not be limited to the following:

1. Audio frequency track circuits, impedance bonds, power bonding, cross bond and negative return connections, and other related track circuit equipment.
2. Power mainline switch-and-lock machines, junction boxes, and associated hardware for attachment to rail track switches.
3. Complete wayside signal assemblies, including junction box bases, foundations, grounding, and all associated hardware.
4. Signal housings and associated foundations and conduit, relays, racks, air conditioners,

and all associated hardware.

5. Power supplies, batteries and chargers, rectifiers, transformers, breaker panels, inverters, converters, and associated power distribution equipment.

6. Signal bungalow, cases, and equipment grounding.

7. Vital microprocessor-based systems, including all necessary hardware and software.

8. Wayside TWC interrogators, loops, loop converters, and associated equipment.

9. Pullboxes.

10. Internal and external wire, cable, tags, CSD manhole racks and cable supports, and associated hardware.

11. Conduit fittings, short runs of conduit, and adjustment of conduits as required to complete the raceway connections to the signal equipment and housings.

B. Compatibility: To ensure cost-effective long-term maintenance by VTA and to minimize disruption to revenue service over the expected 40 to 50 year life of the Signal System, except where expressly approved by VTA through an approved equals process, the manufacturer of essential equipment and key components shall be known and recognized in the industry. The manufacturer shall be a regular manufacturer of the type of equipment being furnished and the equipment shall have been proven in service in similar applications. The equipment shall be identical in form, fit, and function to that provided under other VTA Signal System procurements.

1.04 OTHER MATERIALS AND WORK ITEMS

A. Circuit Design Details and Wiring Diagrams: The Contractor’s shop drawings shall include the following items arranged by location and submitted prior to the beginning of work on equipment house wiring or installation and at the conclusion of the Contract work in as-built configuration:

1. Drawing Index

2. Symbols and Abbreviations Sheet

3. Track and Cable Plans

4. Detailed Circuit Plans

5. Relay Equivalent Logic for Vital Processors

6. Vital Processor Configuration Plans

7. TWC Interrogator Configuration and Programming Plans

8. Power Distribution Plans

9. Terminal Board Details

10. Rack and Room Layouts

B. Installation: The installation Work of this Contract includes all work required to install the equipment of the Signal System. The Work includes all labor, equipment, and material required for the installation process. Work during construction also includes coordination among other disciplines.

C. Removal of Existing Equipment: Removed signal equipment shall be returned, in working order, to VTA, unless directed otherwise by the Resident Engineer.

D. Manuals: Provide maintenance manuals, spare parts lists, adjustment procedures, and technical reference material required for maintenance of the system. Provide manual and spare parts catalogues in both hard copy and electronic format (CD-ROM), as specified in Section 34 42 96, Signal System Support.

E. Training: Provide training to VTA personnel, as specified Section 34 42 96, Signal System Support.

F. Spare Parts, Test Equipment and Tools: Supply spare parts, test equipment, and tools for system maintenance, as specified in Section 34 42 96, Signal System Support.

G. Testing: Perform all tests specified, or required to verify system performance, including testing of components and subsystems, First Article Inspections, factory tests, and field tests, as specified in Section 34 42 95, Signal System Testing.

1.05 VTA FACILITIES

A. The VTA Younger Maintenance Facility may be used for training of VTA staff. Use of the facility will be at the complete discretion of the Resident Engineer, and each use shall require coordination with and approval of the Resident Engineer.

1.06 QUALIFICATIONS OF RAILROAD SIGNAL PERSONNEL

A. The Contractor’s signal system designers responsible for production of the detailed signal design shop drawings shall have at least 10 years’ experience in rail transit signal design, including at least 5 years’ experience with the specific vital processor system being employed on this project and with Vetag compatible TWC systems.

B. Key employees of the Contractor engaged in the final adjustment and testing of the various signaling systems shall be qualified and have had experience on an operating railroad in the type and level of signal installation and testing work as required herein.

C. Signal Engineer as used herein shall be understood to mean Contractor’s railroad signal engineer or engineers approved by the Resident Engineer. Signal Manager as used herein shall be understood to mean Contractor’s railroad signal manager or managers approved by the Resident Engineer.

D. Signal construction and installation personnel shall work under the authority of the Signal Engineer. The Contractor’s signaling construction forces shall work under the authority of a Signal Engineer.

1. Signal Engineer shall plan, direct, and oversee the adjustment, installation, and testing of signal related work and shall coordinate signal work with related track construction work.

2. Signal Engineer shall be responsible for all work under his charge and must have the

authority to remove any personnel from the project who are not performing the work in a satisfactory manner.

3. Signal Engineer shall be on site whenever signal related work or track construction work is in progress in the vicinity of existing wayside signaling equipment, highway grade crossings, and/or cabling.

E. The Signal Managers shall report to and work under the direct authority of the Signal Engineer and shall supervise and direct the work of all signal construction and installation personnel. The Signal Managers shall only perform some major and critical activities, such as cutovers under the direct supervision of the Signal Engineer. Signal Managers shall be required on-site when more than eight personnel are performing signal work, or when signal work is being performed at more than one location, separated by 300 feet or more, at a time.

F. Signal Engineer shall direct and organize the performance of all tests on signaling equipment and systems, under direction of the Resident Engineer, prior to releasing the systems for service. The Signal Engineer shall be responsible to ensure that all applicable test documentation is completed prior to, or immediately after, in-service testing is completed.

G. The proposed Signal Engineer shall demonstrate experience in the philosophy, application, and testing requirements of the various signaling systems. The proposed Signal Engineer shall have a minimum of 10 years signal supervisory or management related experience on a Class I railroad. The proposed Signal Engineer shall also demonstrate knowledge of the governing General Code of Operating Rules, including CPUC and FRA regulations and procedures. This demonstration shall be by interview of the proposed Signal Engineer by the Resident Engineer prior to commencement of any work that may affect the signal system. The work of this project includes working within tight windows on a live railroad consisting of freight trains, inter-city passenger trains, commuter trains, and light rail trains. Candidate shall have a similar level of working experience on Caltrain system. The Resident Engineer's decision concerning the candidate's qualifications will be final. Begin no signaling related work prior to obtaining Resident Engineer’s approval of the Signal Engineer. In addition, obtain the Resident Engineer approval of each Signal Engineer prior to beginning any work that may affect the signal system. Obtain approval of and provide additional Signal Engineers as required depending upon the level and type of work being performed.

H. The proposed Signal Managers shall demonstrate experience in the philosophy, application, and testing requirements of the various signaling systems. The proposed Signal Managers shall have a minimum of 3 years signal supervisory or management related experience on a Class I railroad. The proposed Signal Managers shall also demonstrate knowledge of the governing General Code of Operating Rules, including CPUC and FRA regulations and procedures. This demonstration shall be by interview of the proposed Railroad Signal Managers by the Resident Engineer prior to commencement of any work that may affect the signal system. The work of this project includes working within tight windows on a live railroad consisting of freight trains, inter-city passenger trains, commuter trains, and light rail trains. Candidates shall have a similar level of working experience to Caltrain system. The Resident Engineer's decision concerning the candidate's qualifications will be final. Begin no signaling related work prior to obtaining the Resident Engineer’s approval of Signal Managers. Obtain approval of and provide additional Signal Managers as required depending upon the level and type of work being performed.

I. Propose alternate personnel if the original candidate is found unacceptable. Previous qualification as a Signal Engineer or Manager on other projects does not constitute qualification as a Signal Engineer or Manager for this Contract.

J. The Resident Engineer reserves the right to disqualify any Signal Engineer or Signal Manager at any time during the course of the Work. This right is at the sole discretion of the Resident Engineer and is not subject to protest or appeal.

K. All Contractor field personnel shall receive safety training in accordance with the Contract Documents.

L. The Contractor's Signal Engineer shall be on-site full time, for the full duration of any signal work performed under this contract. The definition of on-site, with regard to the Signal Engineer, shall mean within the Contract limits. The Signal Engineer shall be able to respond to emergency or problem calls 7 days a week, 24 hours a day, within one hour of notification.

1.07 SUBMITTALS

A. Prepare an initial schedule identifying when and how each significant task and associated milestone will be met. The information from this schedule shall be integrated into the overall project Schedule for review and approval by the Authority.

B. Submit individual installation plans, detailing work items, method and means of installation, manpower and durations.

C. Submit materials, equipment, and methods of work to be performed under this Contract as required within the respective section of specifications herein. All submittals shall be site specific and shall indicate the proposed location, application and purpose of material and equipment.

D. The Contractor shall provide all certificates of compliance for all equipment and personnel as required. Manufacturer's Data: Submit Manufacturer's literature, brochures, catalog cuts and materials and installation specifications for the equipment.

E. As-built drawings as specified above in 1.04.A.

F. Manufacturer's data for all major purchased components.

G. Recommended and mandatory spare parts list.

1.08 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 – PRODUCTS

NOT USED

PART 3 – EXECUTION

NOT USED

END OF SECTION 34 42 00

SECTION 34 42 03

RAILWAY SIGNAL SYSTEM OPERATION

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for the operation of the Railway Signal Systems.

1.02 REFERENCED STANDARDS

A. American Railway Engineering and Maintenance of Way Association (AREMA):

1. Part 212 State Safety Participation Regulations.

B. California Public Utilities Commission (Cal. PUC):

1. G.O. No. 75-D Regulations Governing the Protection of Crossings at Grade of Roads, Highways and Streets with Railroads in the State of California.

2. G. O. No. 143-B Safety Rules and Regulations Governing Light-Rail Transit.

C. Federal Railroad Administration (FRA), Code of Federal Regulations:

1. Part 234 Grade Crossing Signal System Safety.

2. Part 236 Rules, Standards, and Instruction Governing the Installation, Inspection, Maintenance, and Repair of Signal and Train Control Systems, Devices, and Applications

D. Santa Clara Valley Transportation Authority:

1. VTA LRT rulebook.

1.03 SUBMITTALS

A. Submit an Operational Description between Alum Rock Station and Eastridge Station. The description should include both normal operation and special event operation.

1.04 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 – PRODUCTS

NOT USED

PART 3 – EXECUTION

3.01 OPERATION BETWEEN ALUM ROCK AND EASTRIDGE STATIONS

A. Operation of Florence Ave. and Wilbur Ave. crossroad intersections.

1. Operation for Florence Ave. crossroad intersection:
Operation will remain as existing – route requests for signals C120, C122, C123 and C125 shall provide input to Florence Ave. traffic controller to begin proper automobile traffic signal phase.

2. Wilbur Ave. crossing operation:
Southbound operation will remain as existing – operator shall stop prior to crossing and proceed with “bar” signal indication. Existing LRT detection loops at the end of platform track area are delayed call/release.
Northbound operation shall be provided by new detection loops placed at stationing 975+84. This provides 25 seconds of warning time to Wilbur Ave. intersection. Loops shall provide activation for northbound moves. When train arrives at intersection, if needed, operator must wait for completion of traffic cycle and proceed with “bar” signal indication.

B. Southbound moves (Alum Rock station to Eastridge station):

1. From Alum Rock station to ABS signals C130/C132.

The southbound routes from the Alum Rock station shall be requested by existing southbound TWC loops. Advanced TWC loop C122AV with any appropriate destination code (as shown on drawings) shall automatically request the route only to the Alum Rock south platform track. If this route is not available (for example, due to a northbound train having requested or locked the northbound route), the request shall be stored until the route is available or is canceled. Local TWC loops C120V, C122V in conjunction with any appropriate code and using the Request button shall also request the route only to the Alum Rock south platform track. All these requests shall establish and lock traffic southbound between Alum Rock and Eastridge station on south track.

TWC loops C120V and C122V shall be able to request a route to the north track using route code 03 (reverse move) and pressing the “Left” button. This request also shall line and lock traffic southbound on the north track between Alum Rock and Eastridge station.

The southbound “Call-On” aspect from the Alum Rock Station to either north or south tracks shall be requested by TWC, using the “Left” or “Right” button on the TWC panel in conjunction with destination code 05, as shown on the drawings. The route shall line and lock traffic southbound between Alum Rock and Eastridge station.

Since traffic between Alum Rock station and Eastridge station is lined and locked, southbound signals C120 and C122 at Alum Rock will be cleared and train can proceed to ABS signals C130 or C132.

2. From ABS signals C130/C132 to ABS signals C134/C136.

Aspects of ABS signals C130/C132 depend on track occupancy conditions ahead (see Route and Aspect Plan). The lowest proceed aspect (yellow) is available when two track circuits ahead are unoccupied (C132AT/C132BT – for south track, C131T/C141FT – for north track).

3. From ABS signals C134/C136 to Eastridge platform tracks.

Aspects of ABS signals C134/C136 depend on track occupancy conditions ahead (see Route and Aspect Plan). The lowest proceed aspect (yellow) is available when all track circuits ahead and before southbound signals (C140/C142) at Eastridge are unoccupied. TWC loops C140AV/C142AV shall provide advanced automatic request of southbound signals (C140/C142) at Eastridge. Preferred route shall be to Eastridge north platform track (C151BT); unpreferred route – to Eastridge south platform track (C142BT). If neither route is available, the request shall be stored until a route is available or is canceled. Operator shall be able manually to cancel all routes and request new routes by using local TWC loops C140V and C142V.

The southbound “Call-On” requests shall be provided by local TWC loops C140V and C142V, using the “Left” or “Right” button on the TWC panel in conjunction with destination code 05, as shown on the drawings.

4. Routes to Eastridge pocket/storage tracks.

For routes to Eastridge pocket/storage tracks new proposed TWC destination codes will be provided: 81 – route to Eastridge north storage track (track AT), 82 - route to Eastridge south storage track (track BT), 83 - route to Eastridge pocket track (track CT). These routes will be automatically requested by advanced TWC loops C140AV/C142AV. If route is not available, the request shall be stored until a route is available or is canceled. Operator shall be able manually to request these routes by using local TWC loops at Eastridge interlocking: C140V, C142V, C150V, C152V.

The southbound “Call-On” aspects on signals C150V or C152V shall be requested by TWC, using the “Left” or “Right” button on the TWC panel in conjunction with destination code 05.

C. Northbound moves (Eastridge station to Alum Rock station):

1. From Eastridge station to ABS signals C131/C133.

The northbound routes from Eastridge pocket/storage tracks shall be requested by TWC, using the “Request” button on the TWC panel in conjunction with an appropriate destination code, as shown on the drawings.

Routes from pocket track AT.
Request from TWC loop C151V shall request the route to the north platform track (C151BT). The same request shall request the route to exit signal C140 and shall line and lock traffic northbound from Eastridge station to Alum Rock station. If the route to the north platform track is unavailable the request shall be stored until the route is available or is canceled. If the route to the north platform track is available, but the route to exit signal C140 is unavailable, the operator shall move the train to the north platform track and then request a route to exit signal C142 using route code 03 (reverse move) and pressing the “Left” button; this request also shall line and lock traffic northbound on the south track between Eastridge station and Alum Rock station.

Routes from pocket track BT.
Request from TWC loop C155V shall request the route to south platform track (C142BT). The same request shall request the route to exit signal C140 and shall line and lock traffic northbound from Eastridge station to Alum Rock station. If the route to the south platform track is unavailable the request shall be stored until the route is available or is canceled. If the route to the south platform track is available, but the route to exit signal C140 is unavailable, the operator shall move the train to the south platform track and then request a route to exit signal C142 using route code 03 (reverse move) and pressing the "Left" button; this request also shall line and lock traffic northbound on the south track between Eastridge station and Alum Rock station.

Routes from storage track CT.
Request from TWC loop C153V shall request the route to the north platform track C151BT (preferred route) or to south platform track (unpreferred route) by pressing button "Request" and in conjunction with an appropriate code. The same request shall request the route to exit signal C140 and shall line and lock traffic northbound from Eastridge station to Alum Rock station. If both routes to the platform track (preferred and unpreferred) are unavailable the request shall be stored until route is available or is canceled. If the route to exit signal C140 is unavailable, the operator shall move the train to either platform track and then request a route to exit signal C142 using route code 03 (reverse move) and pressing the "Left" button; this request also shall line and lock traffic northbound on the south track between Eastridge station and Alum Rock station.

The northbound "Call-On" aspects shall be requested by TWC, using the "Left" or "Right" button on the TWC panel in conjunction with destination code 05, as shown on the drawings. The routes shall line and lock traffic southbound between Alum Rock and Eastridge station.

2. From ABS signals C131/C133 to Alum Rock station.

Aspects of ABS signals C131/C133 depend on track occupancy conditions ahead (see Route and Aspect Plan). The lowest procced aspect (yellow) is available when two track circuits ahead are unoccupied (C129T/C132AT – for south track, C127T/C131T – for north track). Train moves north to northbound signals C123/C125 at Alum Rock station.

3. From Alum Rock station to exit signals C120C/C122.

TWC loops C123AV/C125AV shall provide advanced automatic request of northbound signals (C123/C125) at Alum Rock station. Route shall be requested to exit signal C120. If this route is unavailable the request shall be stored until the route is available or is canceled. Using local TWC loops C123V/C125V operator can request the route to exit signal C122 using route code 03 (reverse move) and pressing the "Left" button.
No "Call-on" routes will be provided from signals C123/C125 to exit signals C120/C122.
See part 3.02.A for operation of Florence Ave. and Wilbur Ave. crossroad intersections located within Alum Rock station area.

D. For special events, or when other moves are required, routes shall be able to be selected either from OCC, a local control panel, or from the TWC system. TWC selections shall be as described above and as defined on the drawings. TWC route request will only be effective when no conflicting or opposing routes are established. A TWC cancel function will only be able to cancel a route from the signal at the TWC loop, unless described otherwise. OCC and the LCPs shall have the ability to cancel all routes.

3.02 TESTING REQUIREMENTS

A. General: Perform a visual inspection to verify that all equipment has been installed and is ready for test. Utilizing the arrangement drawings, verify that all wiring is in place and equipment tags are correct, and indicate as such with a green pencil on the approved Location Plans.

B. Static Testing: Verify that:

1. Track circuit equipment has been placed and installed as shown on the contract drawings.
2. Track circuit equipment is wired according to the up-to-date and approved Location Plans. Correct wiring shall be indicated as such by marking with a green pencil.
3. Track circuit equipment wiring identification tags and markers are in place.
4. Track circuit equipment is energized with the correct voltages.
5. With no train occupying the track circuit, corresponding track relay picks.
6. With a .20Ω test shunt, shunt each end of the track circuit, and through any turnouts, corresponding track relay drops.

C. Operational Testing: Refer to Section 34 42 95, Signal System Testing for requirements.

D. Dynamic Testing: Refer to Section 34 42 95, Signal System Testing for requirements.

E. Integration Testing: Refer to Section 34 42 95, Signal System Testing for requirements.

3.03 FIELD QUALITY CONTROL

A. Quality: The quality of the wayside signal system installation shall be ensured through the performance of tests and inspections made during the progress of this Contract and after completing the installation of equipment. Perform field installation inspections to ensure that all equipment furnished under this Contract is installed in compliance with the technical specifications.

END OF SECTION 34 42 03

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SECTION 34 42 10

INTERLOCKINGS

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes the requirements for furnishing, installing, and testing microprocessor-based systems (including interlocking vital microprocessors, coded track circuit microprocessors, event recorders) and associated local control panels.

1.02 REFERENCED STANDARDS

A. American National Standards Institute (ANSI):

1. C.37.90.1 Guide for Surge Withstand Capability (SWC) Test.

B. American Railway Engineering and Maintenance of Way Association (AREMA):

1. Part 1.5 Recommended Instructions for the Installation and Maintenance of Solid State Equipment.
2. Part 3.1.25 Recommended Design Criteria and Functional Guidelines for Solid State Highway-Rail Crossing Warning Device Controllers.
3. Part 11.2.1 Recommended General Practices for Electrical Surge Protection of Signal Systems.
4. Part 16.2 Recommended Symbols.

C. California Public Utilities Commission (Cal. PUC):

1. G. O. No. 143-B Safety Rules and Regulations Governing Light-Rail Transit.

D. Federal Railroad Administration (FRA), Code of Federal Regulations:

1. Part 236 Rules, Standards, and Instruction Governing the Installation, Inspection, Maintenance, and Repair of Signal and Train Control Systems, Devices, and Applications.

1.03 SUBMITTALS

C. Vital Microprocessor Product Data: Submit product information for the microprocessor. Include all product data, assembly drawings, circuits, parts lists, and printed circuit board layouts. Include a functional block diagram for the vital microprocessor system components. Submit manuals describing preparation of application logic for the microprocessors.

D. Event Recorder/System Monitoring Unit Product Data: Submit product data for the event recorder/system monitoring units, including cabling and all supporting equipment.

C. Coded Track Circuit Product Data: Submit product data for the coded track circuit microprocessor, and the

AC interface to allow the system to operate in DC electrified territory, including cabling, hardware, and all support equipment. Include all product data, assembly drawings, circuits, parts lists, printed circuit board layouts, and support calculations. Provide a functional block diagram for the coded track circuit system components.

D. Local Control Panel Product Data: Submit product information for the Eastridge local control panels. Include all product data, assembly drawings, circuits, and parts lists.

E. Test Reports: Submit test reports verifying compliance with testing requirements, per the requirements of Section 34 42 95, Signal System Testing.

1.04 MEASUREMENT AND PAYMENT

A. Measurement: Interlockings shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Interlockings shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in this Section, complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 GENERAL REQUIREMENTS

A. General: Microprocessor-based systems, including the local control panel, shall operate:

1. In temperatures of -40 degrees C (-40 degrees F) to +70 degrees C (158 degrees F).

2. Over a range of relative humidity from 0 to 95 percent non-condensing.

3. From 10 Vdc to 16 Vdc, maintained by a traditional battery-rectifier supply. A requirement for a special power supply or UPS is not acceptable. Connections to external circuits shall be designed to interface to standard signal equipment operating at normal voltages for the type of equipment.

4. Without forced air ventilation.

B. Microprocessor Units:

1. Equipment shall be rack mounted in card file modules, complete with accessories, and shall be modular in design.

2. Utilize keying to prevent improper insertion of circuit boards.

3. Provide the capability to communicate with other systems, both vitally and non-vitally, as required by the specific application.

4. Units shall collect all the required data and interface to SCADA to communicate between signal housings and OCC, between signal housing and signal housing, interface with the TWC System, and interface with the event recorder/system monitoring unit which will transmit indications to SCADA. Interfaces to SCADA shall be provided via serial links, utilizing a Genisys protocol, fiber optic cable and associated modems, where Signals and Communications are not co-located in

the same housing. Where co-located in the same housing, interface directly to channel cards in the Communications equipment via an Ethernet or RS-232 interface.

5. Equip with the appropriate type and quantity of circuit boards to perform all functions, including a modem, for interfacing to SCADA. If the Contractor's standard product does not come equipped with a built-in modem, provide an external modem.

6. SCADA shall set the date/time of all clocks in all remote units at least once every 12 to 24 hours and after a loss of communications. All microprocessor equipment reporting to OCC via SCADA shall be provided with the ability to accept a date/time set message from SCADA.

7. Plug-in printed circuit cards shall be used wherever possible and they shall be keyed or configured such that a card cannot be installed in the incorrect position.

8. Electronic components, except primary surge protection and voltage adjusting resistors, shall be mounted on plug-in circuit cards or plug coupled subassemblies to facilitate testing and maintenance.

9. Provide a summary trouble alarm of all microprocessor-based systems, with the exception of the vital interlocking microprocessor which shall have its own independent trouble alarm, to the event recorder and send to SCADA.

C. Safety:

1. Vital microprocessor-based units shall be designed using the closed loop principle to achieve safety.

2. Vital microprocessor-based units, especially with respect to outputs, shall react in a safe manner to all failure modes. The unit shall not continue system control if it fails to pass system integrity tests.

3. Design complete with all necessary lightning and surge protection for the equipment itself, the input and outputs, and the system as a whole, entirely adequate for the electrical environment and the equipment being operated.

4. The manufacturer's method of making changes to the programs shall prevent accidental or unintentional changes. Erasable portions of memory must have the appropriate physical or electrical protections to prevent unauthorized or accidental changes. All vital firmware must have complete identification on each individual ROM or other storage devices to prevent the application of the programming to the wrong location.

5. Hardware whose failure modes may adversely affect the safe implementation of a vital function, but which is not designed as vital hardware shall be considered vital. Failure modes in this hardware shall be revealed or otherwise accounted for by means other than vital hardware design techniques. These means include, but are not limited to, software checking and comparison of independent hardware circuits.

6. Equip with onboard diagnostics to detect failed printed circuit boards or other hardware, as specified herein. The operation of any diagnostics that may change software routines or otherwise compromise safety shall be accessible through a hardware or software security system designed to warn the user that a dangerous situation may be created.

7. Divide the operating instructions for the vital microprocessor into executive and application dependent portions. The use of electrically erasable programmable ROM (e.g., flash memory) is acceptable. Store the executive instructions in solid state read only memory (ROM) or solid state

programmable read only (PROM) devices and as the Executive Firmware. Store the application dependent instructions in solid state programmable read only memory (PROM) devices and designate as the Application Dependent Firmware.

D. Serial Links:

1. If the Contractor's design requires more than one microprocessor per location, the microprocessor system shall provide vital serial links between the processors. The use of more than one processor to control an interlocking must be approved prior to design. Serially transmitted data between subsystems shall be updated every second to ensure integrity of the communication link.

2. Serial communications between processors implementing vital functions shall be vital. Security protocol, including handshaking and error detection, shall be used to ensure the validity of data. Data shall default to the most restrictive state unless a valid transmission is received. Serially transmitted data between subsystems shall be repeatedly updated to ensure the integrity of the communications link. The interlocking control system shall support a minimum of one spare vital serial link.

3. Non-vital serial communications shall be provided and shall consist of the transmission of data between the vital processor and SCADA, and to an EIA-compatible modem for future remote communications.

E. Documentation:

1. Provide a complete and detailed hard copy print out, and an electronic copy, of all vital and non-vital software for each location per the requirements of 34 42 00, General Signaling Requirements. The programs shall be modularized in a logical and easily understood manner. Each module shall be fully annotated, including revision blocks, with plain English explanations of the function of each module and the methods and means it uses to accomplish its tasks. Include for all related modules required to take part in the execution of the instructions.

2. Identify all data passed from one vital controller to another vital controller and all data passed from any vital controller to the non-vital controller, local control processor, as well as hardwire interfaces. Identify all terms in the Boolean or ladder expressions and all data received by or sent from the controllers with standard relay logic nomenclature. Translation tables will not be accepted.

F. Timers: Provisions shall be made in the design to adjust all functions requiring adjustable timers (e.g., grade crossing activation, route request delayed-on calls) without changing program software. Install timers external to the processors if necessary. Timers shall meet the requirements of Section 34 42 27, Railway Control Equipment – Relays.

G. Local control panel:

1. Local control panel equipment shall be mounted in sufficiently sized cabinet to accommodate faceplate track layout.

2.02 VITAL INTERLOCKING MICROPROCESSOR

A. General: The vital microprocessor-based unit shall be ElectroLogIXS manufactured by Alstom Signaling or an "owner approved equal." The microprocessor shall utilize a Genisys protocol, and shall:

1. Be capable of providing direct vital control of wayside LED signals.

2. Operate according to the requirements established by the AREMA for the control and indication of safety functions performed by vital relays.

3. Be programmed to accurately reflect the relay logic design and functions of the Contract Documents. All functional and operational safety features provided by the use of vital relays and relay logic design shall be maintained by the system and its application programming. Operational and safety features derived because of relay characteristics and inherent in relay logic design, utilized in the system operation, shall be functionally maintained in the system.

4. Provide all controls, indications, safety checks, and all other functions required for the signal system. The processor shall be capable of receiving route requests form OCC, as well as locally from the LCP and TWC System.

B. Connections: Connections to external non-electronic vital signal apparatus shall be on binding posts or other solderless connectors, as approved by the Resident Engineer.

C. Inputs/Outputs (I/O):

1. The microprocessor system shall provide for vital and non-vital inputs. A visual indication, such as an LED, shall be provided for each input on the input board. It shall illuminate continuously when the input is activated. Vital inputs for the equipment shall have an option to selectively debounce each input. Vital inputs shall be electrically and physically vitally isolated from each other.

2. The microprocessor shall provide vital and non-vital outputs. A visual indication, such as an LED, shall be provided for each output on the output board. It shall illuminate continuously without use of a pushbutton when the output is activated. Vital outputs shall be electrically and physically isolated from the logic power supply. If output is used to drive double break circuitry, the output shall be physically and electrically isolated from each other.

3. Inputs shall be buffered and shall be immune to contact bouncing and shall be electrically and physically isolated from one another per AREMA requirements for vital circuits. Access to inputs must be unique in the sense that under failure, reading of the incorrect input circuit will not result in a falsely permissive input being utilized in vital processing.

4. A label shall be provided for each input and output indication which denotes the respective function of each to facilitate troubleshooting and maintenance.

5. A falsely permissive non-vital input shall not adversely affect the safety of the vital function processing.

6. Outputs shall be electrically and physically isolated from one another per AREMA requirements for vital circuits. Single break type outputs may have a common reference. A vital means of verifying the proper state of the output shall be provided. Access to the outputs shall be unique in the sense that under failure, writing to the wrong output circuit will not result in a falsely permissive output being generated. Processor communication with each output shall vitally assure that the proper output is in the proper state (on or off).

7. The vital processor shall assure correspondence of each vital output between the actual and requested states. The actual output state shall correspond to the requested state within 120ms. No output shall remain active when requested inactive. Means shall be provided to assure the capability to remove all energy from a failed vital output. Wherever possible, the system should be fault-tolerant such that single output failures do not force a system shutdown, unless the state of a vital output is potentially unknown.

D. Internal Diagnostics: The processor subsystem shall incorporate vital self-checking tests to ensure the equipment and program is functioning as intended. The checks shall be integral parts of both hardware and software to provide for a secure system.

1. The vital processor shall not allow false information to persist long enough to allow an unsafe condition to occur or allow false information to be transmitted to external devices which will create a hazardous condition. Processor shall use a vital "kill" relay circuit to de-energize all outputs in the event of a safety related I/O or processor failure. The "kill" circuit shall de-energize all outputs in a time less than the fastest activation time of any external device connected to a vital output. The kill circuit shall use vital circuit design techniques to assure that no false signal that could be generated by any other device in the relay housing (e.g., power supplies, audio or coded equipment), or harmonics of these devices shall energize the output power relay.

2. Provide visual indicators, such as LEDS, to demonstrate that the system is functioning as intended; similarly provide failure and diagnostic indications. Indicators shall isolate a failure to a particular function, or the interface between two functions.

3. Transmission of false information from a non-vital to a vital subsystem shall not affect the safety of the vital subsystem.

4. System outputs shall be positively monitored with independent current/voltage sensors and compared to the requested value. The "kill" circuit shall de-energize all outputs and shutdown the system when the outputs fail to correspond to the required state or a more restrictive state. Diagnostic checks shall act on current (fresh) data only. Memory locations used to determine the proper states of inputs and outputs shall be cleared or overwritten prior to being reused during each cycle of tests to ensure the integrity of the check. The diagnostic checks shall be independent of the application logic for the system. The system shall attempt an automatic restart after executing safety checks.

5. Diagnostics shall check to assure synchronized tasks shall execute correctly in the proper order. Checks shall shutdown the system in the event the processor is overloaded.

6. PROMS and EPROMS shall be checked, as part of program execution, during each cycle, to ensure they have been unaltered during processor execution. Benchmarks shall be created for blocks of memory to implement these tests.

E. Power Supply: Each microprocessor unit shall operate on the nominal 12 Vdc power source, and battery backup, provided by the Contractor, unless specified otherwise. Refer to Section 34 42 41, Power Distribution Batteries and Chargers, for requirements.

F. Access: A method of security shall be provided to allow only authorized user access. The system shall not interfere with operation of the wayside vital processor system.

G. Troubleshooting: The microprocessor system shall be capable of interconnection to a portable laptop that permits interrogation (via keyboard/keypad) and observation (via monitor/display) of internal logic bits during testing and normal operations. This interface shall use English-Text and Arabic numeral nomenclature with explanation of faults in easy to read text. Operator interface shall be via menu driven commands with an on-line HELP feature to describe use of commands.

H. Noise: The microprocessor system shall be designed to operate in the presence of the following noise sources:

1. Lightning surges and voltage surges from external power distribution systems;

2. Transients from nearby power lines, propulsion return currents, back EMF from operating relay coils, arcing contacts, RF noise such as hand-held radios and;

3. I/O wiring from the I/O card file to external terminal strips.

I. Site Specific Application Software: The Contractor shall design and provide application logic software for the vital processor.

J. Modems:

1. If not provided as part of the microprocessor unit, provide a separate modem for communications between signal and crossing houses. Include with the modem unit, mounting hardware, power supply, cable, connectors, and all other equipment required for configuration, operation, and testing.

2. Provide RS-232 serial and Ethernet cables, for interconnections between the microprocessors and the Communications System when not co-located with a Communications hub.

3. Provide additional fiber and fiber optic modems, if required, to transmit information between signal crossing houses and interlocking signal houses. When communicating between signal devices, convert the data into a form suitable for the devices to properly, and vitally where required, interpret the data (interlocking vital microprocessor to interlocking vital microprocessor, GCP to GCP).

4. Power each modem using a dc to dc converter, to provide isolation from the Communications System, as specified in Section 34 42 41, Power Distribution Batteries and Chargers.

5. Provide isolation transformers and other necessary circuitry to provide ac and dc overvoltage protection, if necessary, on the line connection.

6. Provide independently selectable transmit levels and impedance.

7. Provide diagnostic capabilities for performing local analog and local digital remote loopback.

8. Provide front panel indications from transmit data, receive data, request to send, data carrier, power, remote power fail, and test.

9. Provide a data rate sufficient to ensure that a detected event at the signal housing will arrive and be dated in order to be recorded by the Communication System within 1 second of the actual occurrence.

10. The microprocessor shall record all functions in plain English, at the time the event actually occurred. Event logs shall be readable without requiring numeric to alphanumeric conversion.

11. Provide accurate and reliable sequence of event reporting in the playback mode.

K. Communications Data Server

1. Provide communications data server to convert serial data output from the vital processor to Ethernet for connection to the SCADA system.

2.03 EVENT RECORDER/SYSTEM MONITORING UNIT

A. General:

1. Provide an event recorder/system monitoring unit at all LRT signal housings to record all controls and indications, as well as additional functions required by Cal. PUC GO No. 143-A. An event recorder is not required if the vital microprocessor-based equipment provided can store the same information under the same conditions, as specified herein.

   a. The event recorder/system monitoring unit shall include an Ethernet communications port to interface to SCADA to send indications to OCC.

   b. Recorders shall utilize a Genisys protocol.

2. Provide sufficient memory to store a minimum of 7 days' worth of normal VTA operations being monitored without loss of any data (e.g., without overwriting the first recorded occurrence of that week period). Provide a data rate sufficient to ensure that a detected event at the signal housing/room/case will arrive and be dated in order to be recorded by the Communication System within 1 second of the actual occurrence.

3. Provide a unit that is capable of generating alarm status based on user definable conditions.

4. Provide a unit that is capable of being configured, monitored, and tested by a laptop computer, connected locally. The unit shall be Windows-based and shall be user friendly.

5. The unit shall record all functions in plain English, at the time the event actually occurred. Event logs shall be readable without requiring numeric to alphanumeric conversion.

6. Provide accurate and reliable sequence of event reporting in the playback mode.

7. The unit shall be set up such that it may be dumped on demand, through SCADA, via a dial up modem.

8. Provide a dc to dc converter for each modem, to provide isolation from the Communications System, per the requirements of Section 34 42 41, Power Distribution Batteries and Chargers.

2.04 CODED TRACK CIRCUITS

A. General: Provide coded track circuit microprocessor-based units for train detection and block control, with the exception of circuits within interlockings, which shall utilize AFO track circuits. Refer to Section 34 42 11, Track Circuits for additional requirements. The unit shall be Electro Code 5, manufactured by Alstom Signaling, or "owner approved equal." A separate coded track circuit microprocessor unit is not required if the vital microprocessor supplied can provide the same functions under the same conditions.

2.05 LOCAL CONTROL PANEL

A. General: The local control panel shall be a Computer Based Control Panel. The local control panel shall:

1. Be capable of serial communication with microprocessor.

2. Contain a site-specific track layout on the faceplate, as shown on contract drawings.

3. Contain all necessary controls and indications as shown on contract drawings.

PART 3 – EXECUTION

3.01 INSTALLATION

A. General:

1. Provide all units complete with mounting hardware, power supply, cables, connectors, and all other miscellaneous equipment and material required for configuration, operation, and testing.

2. Mount all equipment, including associated power supply and support equipment, in the wayside signal housing/room/case. Refer to Section 34 42 40, Signal Equipment Housings for additional requirements.

3. Provide the required ventilation and protection from dust and moisture, either as part of the individual unit, or as part of the signal housing/case.

4. Install microprocessor equipment per the recommendations of AREMA, Part 1.5.

5. Before proceeding with any software upgrade, employ electrostatic discharge precautions to ensure that PROM internal circuits are not accidentally damaged by high static voltages or electrostatic fields. Such precautions shall include, but not be limited to:

   a. Except when necessary, avoid touching the PROM leads.

   b. Use integrated circuit extractor/inserter tools designed to remove and install electrostatic PROMs.

   c. When replacing PROMs, always lay the module on the electrostatic bag provided by the manufacturer, not on the work surface.

   d. Following removal, old PROMs shall be inserted into conductive foam material.

B. Noise Mitigation: Suppress or prevent noise from entering into the system using the following practices:

1. Use lightning arrestors and secondary surge suppressers to protect against lightning and other voltage surges, in accordance with AREMA Signal Manual, Part 11.2.1.

2. Ground all card files, modems and other system components to the cabinet ground stud to earth ground through a capacitor to establish ground.

3. Connect shields on serial communication cables to earth ground on one end only.

4. Provide required load to unused outputs.

5. Ensure proper pickup and dropaway relay currents per relay specifications when interfacing relays to I/O cardfiles.

6. Install standard suppression on all relay coils.

7. Use twisted pair wires for all inputs.

8. Shorten wire harnesses from I/O cardfiles to external terminal strips and dress these wires away from the CPU.

9. "Oversize" power supplies and design associated power busses to minimize noise produced by voltage drop of transient currents. External filtering may be used to reduce transient current noise on the power bus.

10. Separate connections to external apparatus from internal wiring carrying processor signals.

11. Keep cabling between cardfiles as short as possible to minimize induced noise and group microprocessor-based system racks together, although sufficient slack shall be provided for a service loop.

12. Mitigate the effects of noise, transients and grounds that appear on inputs and outputs to the system. Cable conductors and track mounted devices are regularly exposed to water and traction power induced transients. System instability, processor rest or processor shutdown shall not be a normal response to these input and output conditions.

C. Ethernet Cable: Install Cat 6 cable between the Signal and Communications equipment.

D. Maintenance: To facilitate maintenance, diagnostics shall be organized such that detectable failures will energize LED indicators mounted on the edge of either the individual PC cards, or on a centralized board, which will allow a technician to determine system operating status and errors. A method of security shall be provided to allow only authorized user access. The security system shall not interfere with operation of the vital microprocessor subsystem.

E. Marking and Tagging: Event recorders/system monitoring units, microprocessors, TWC interrogators, and their associated modems, shall be labeled in the same format as that used for labeling SCADA. Coordinate specific nomenclature with the Communications System design. Refer to Section 34 42 22, Signal Internal Wiring for additional requirements.

3.02 TESTING REQUIREMENTS

A. General: Conduct a visual inspection to verify that all equipment has been installed and is ready for test. Utilizing the arrangement drawings, verify that all wiring is in place and equipment tags are correct, and indicate as such with a green pencil on the approved Location Plans.

B. Factory Testing: Perform a functional test and/or wiring verification in accordance with approved test procedures and circuit drawings. Simulate functions external to the housing, racks, and cases, where required, and to the greatest extent possible. Certified test reports shall be submitted to the Resident Engineer before shipment, showing successful completion of each test.

C. Static Testing: The microprocessor-based systems are required to function the same as the equivalent vital and non-vital relay logic system and shall be tested accordingly. The new signal racks, including the microprocessor and its software, shall be pre-tested prior to installation

1. Vital Microprocessor Checkout: Verify that:

   a. When copies of the executive and application software for the main system are made, for both the original and spare EPROMs, bit by bit verification test of each copy using an EPROM programmer shall be performed to ensure the copies are identical to the original.

   b. When the executive or application software is changed, re-test the entire microprocessor based system each time.

   c. Retesting the system is not required when the application EPROM is replaced or when spare EPROM is installed, provided the software resident within the new or spare EPROM has been verification-tested bit by bit.

   d. The "kill" circuit de-energizes all outputs and shutdown the system when the outputs fail to correspond to the required state or a more restrictive state.

   e. The system attempts an automatic restart after executing safety checks.

f. Diagnostic visual indicators are functioning properly.

g. Switch and signal control, traffic, route logic, and all other functions operate properly, per the requirements herein.

h. Power supplies associated with the microprocessor based system shall be adjusted and calibrated.

2. Crossing Control: Refer to Section 34 42 12, Grade Crossing Warning Signals for requirements.

D. Operational Testing: Refer to Section 34 42 95, Signal System Testing for requirements.

E. Dynamic Testing: Refer to Section 34 42 95, Signal System Testing for requirements.

F. Integration Testing: Refer to Section 34 42 95, Signal System Testing for requirements.

3.03 FIELD QUALITY CONTROL

A. Quality: The quality of the wayside signal system installation shall be ensured through the performance of tests and inspections made during the progress of this Contract and after completing the installation of equipment. Perform field installation inspections to ensure that all equipment furnished under this Contract is installed in compliance with the technical specifications.

END OF SECTION 34 42 10

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SECTION 34 42 11

TRACK CIRCUITS

PART 1 – GENERAL

1.01 SUMMARY

A. This section includes the requirements for furnishing, installing, and testing audio frequency overlay (AFO) track circuit equipment, as well as general requirements applicable to coded track circuit equipment.

1.02 REFERENCED STANDARDS

A. American Railway Engineering and Maintenance of Way Association (AREMA):

1. Part 8 Track Circuits.

2. Part 8.1.1 Recommended Functional/Operating Guidelines for Track Circuits.

B. California Public Utilities Commission (Cal. PUC):

1. G.O. No. 75-D Regulations Governing the Protection of Crossings at Grade of Roads, Highways and Streets with Railroads in the State of California.

2. G. O. No. 143-B Safety Rules and Regulations Governing Light-Rail Transit.

C. Federal Railroad Administration (FRA), Code of Federal Regulations:

1. Part 234 Grade Crossing Signal System Safety.

2. Part 236 Rules, Standards, and Instruction Governing the Installation, Inspection, Maintenance, and Repair of Signal and Train Control Systems, Devices, and Applications.

1.03 SUBMITTALS

A. Audio Frequency Overlay (AFO) Track Circuit Data: Submit product information and drawings for AFO track circuit equipment, including cabinets, modules, and all related equipment. Include all part numbers, dimensions, specifications, and adjustment procedures.

B. Coded Track Circuit Product Data: Refer to Section 34 42 10, Interlockings for requirements for submitting coded track circuit product data.

C. Impedance Bond Data: Submit product information and drawings for impedance bonds. Include all part numbers, dimensions, specifications, and tuning procedures. Provide curves of impedance versus frequency from 60 Hz through 10 kHz. Provide test report in accordance with AREMA Communications and Signals Manual Part 8.4.3.

D. Test Reports: Submit test reports verifying compliance with testing requirements, per the requirements of Section 34 42 95, Signal System Testing.

1.04 QUALITY ASSURANCE

A. Cal. PUC: Installation shall conform to regulations established in the Cal. PUC G.O. No. 75-D.

B. AREMA: Installation of track circuits shall conform to the recommendations of AREMA, Part 8, unless specified otherwise. Where the requirements of AREMA, or these technical specifications conflict, the most stringent shall govern.

C. FRA: Installation of track circuits shall conform to the requirements of FRA Parts 234 and 236. Where the requirements of the FRA or these technical specifications conflict, the most stringent shall govern.

1.05 MEASUREMENT AND PAYMENT

A. Measurement: Track Circuits shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Track Circuits shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in this Section, complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 GENERAL

A. AFO Track Circuits: Provide new AFO track circuit equipment at Eastridge, Alum Rock (replace existing audio frequency track circuits) and Story, as shown on the drawings. Equipment shall be installed in Eastridge bungalow. New AFO track circuit equipment shall be PSO 4000 as manufactured by Siemens Rail Automation (formerly Safetran), or owner approved equal. The Contract Drawings list the track circuits that shall be new equipment.

B. Coded Track Circuits: The design of coded track circuits shall adhere to the general requirements herein, unless specified otherwise. Refer to Section 34 42 10, Interlockings for additional requirements.

C. Impedance Bonds: Provide new impedance bonds, as shown on the drawings. Impedance bonds shall be rated for a minimum of 1000 amps per rail continuous, and 1500 amps per rail continuous for substation negative return connection.

PART 3 – EXECUTION

3.01 TRACK CIRCUIT EQUIPMENT INSTALLATION

A. Locations: Install track circuit equipment as indicated on the Contract Drawings.

B. General:

1. Install track circuit equipment in accordance with the provisions of the AREMA Manual, Part 8, and the Contract Drawings.

2. Install equipment in accordance with the manufacturer's recommended procedures.

3.02 TESTING REQUIREMENTS

A. General: Perform a visual inspection to verify that all equipment has been installed and is ready for test. Utilizing the arrangement drawings, verify that all wiring is in place and equipment tags are correct, and indicate as such with a green pencil on the approved Location Plans.

B. Static Testing: Verify that:

1. Track circuit equipment has been placed and installed as shown on the Contract Drawings.
2. Track circuit equipment is wired according to the up-to-date approved Location Plans. Correct wiring shall be indicated as such by marking with a green pencil.
3. Track circuit equipment wiring identification tags and markers are in place.
4. Track circuit equipment is energized with the correct voltages.
5. With no train occupying the track circuit, corresponding track relay picks.
6. With a 0.20Ω test shunt, shunt each end of the track circuit, and through any turnouts, corresponding track relay drops or corresponding input de-energizes.

C. Operational Testing: Refer to Section 34 42 95, Signal System Testing for requirements.

D. Dynamic Testing: Refer to Section 34 42 95, Signal System Testing for requirements.

E. Integration Testing: Refer to Section 34 42 95, Signal System Testing for requirements.

3.03 FIELD QUALITY CONTROL

A. Quality: The quality of the wayside signal system installation shall be ensured through the performance of tests and inspections made during the progress of this Contract and after completing the installation of equipment. Perform field installation inspections to ensure that all equipment furnished under this Contract is installed in compliance with the technical specifications.

END OF SECTION 34 42 11

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SECTION 34 42 12

GRADE CROSSING WARNING SIGNALS

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for furnishing, installing, and testing pedestrian crossing warning systems, and interfaces to street traffic control systems for automobile traffic coordination.

1.02 REFERENCED STANDARDS

A. American Railway Engineering and Maintenance of Way Association (AREMA):

1. Part 3 — Highway-Rail Grade Crossing Warning Systems.

B. California Public Utilities Commission (Cal. PUC):

1. G.O. No. 75-D — Regulations Governing the Protection of Crossings at Grade of Roads, Highways and Streets with Railroads in the State of California.

C. Federal Railroad Administration (FRA), Code of Federal Regulations:

1. Part 234 — Grade Crossing Signal System Safety.
2. Part 236 — Rules, Standards, and Instruction Governing the Installation, Inspection, Maintenance, and Repair of Signal and Train Control Systems, Devices, and Applications.

D. Manual of Uniform Traffic Devices (MUTCD):

1. Part 8 — Traffic Control Systems for Railroad: Highway Grade Crossings
2. Part 10 — Traffic Controls for Highway-Light Rail Transit Grade Crossings

1.03 SUBMITTALS

A. Crossing Control Product Data: Submit information on the new controls for the Eastridge pedestrian crossings, including the vital microprocessor logic.

B. Test Reports: Submit test reports verifying compliance with testing requirements, per the requirements of Section 34 42 95, Signal System Testing.

1.04 QUALITY ASSURANCE

A. Cal. PUC: Installation shall conform to regulations established in the Cal. PUC G.O. No. 75-D.

B. AREMA: Installation shall conform to the recommendations of AREMA, Part 3, unless specified otherwise. Where the requirements of AREMA, or these technical specifications, conflict with requirements of Cal. PUC G.O. No. 75-D, the Cal. PUC shall govern.

C. FRA: Installation of crossing warning systems shall conform to the requirements of FRA Parts 234 and 236. Where the requirements of the FRA or these technical specifications conflict, the most stringent shall govern.

D. MUTCD: Installation shall conform to the regulations established in MUTCD Parts 8 and 10, unless specified otherwise.

1.05 MEASUREMENT AND PAYMENT

A. Measurement: Grade Crossing Warning Signals shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Grade Crossing Warning Signals shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in this Section, complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 GENERAL

A. There are two existing crossroad intersections at Alum Rock station area: Florence Ave. and Wilbur Ave. At those intersections automobile and pedestrian movements are governed by traffic signals only, there are no gates or flashers; train movements are governed by “bar” signals. “Bar” signals are controlled by Traffic Signal system. Traffic Signal system receives inputs either from detection loops or Train Signal system, as shown on the drawings.

B. Eastridge station area will be provided with pedestrian gates (equipped with bells and flashers) for entering/leaving the platform, as shown on the drawings.

PART 3 – EXECUTION

3.01 CROSSING CONTROL

A. Florence Ave. crossroad intersection:

Operation for Florence Ave. crossroad intersection will be as at presently – route requests for signals C120, C122, C123 and C125 shall provide input to Florence Ave. traffic controller to begin proper automobile traffic signal phase. No changes under this project shall be provided for this crossroad.

B. Wilbur Ave. crossroad intersection:

Southbound operation will remain the existing - operator shall stop near crossing and proceed with “bar” signal indication. Existing LRT detection loops at the end of platform track area are delayed call/release.

Northbound operation shall be provided by new detection loops placed at stationing 975+84. This provides 25 seconds of warning time to Wilbur Ave. intersection. When train arrives at intersection operator if needed must wait completion of traffic cycle and proceed with “bar” signal indication.

C. Pedestrian Crossings at Eastridge station:

1. Northbound activation: Activation of these pedestrian crossings for northbound movements will be provided by requesting signals C151/C153 to the south platform track. These signals shall be cleared with a delay of 25 seconds.

2. Southbound activation: It is inadvisable to activate these pedestrian crossings by requesting signals C140/C142, because of their advanced automatic request from distant TWC loops at Story station. Therefore, approach track circuits shall be used for this purpose.

D. General:

1. The crossing controller system shall interface with the vital microprocessor, as applicable, and meet applicable requirements in AREMA Signal Manual Parts 3.1.25 and 3.1.26, unless specified otherwise.

2. Bells and flashers shall activate a minimum of 25 seconds before a train enters the crossing.

3. Crossing Activation: Delayed crossing activation, whether performed by microprocessor-based equipment or through the use of external timers, shall be performed vitally, in accordance with the requirements of Cal. PUC General Orders.

4. If a signal (used for activation of crossing) is cancelled, the crossing shall continue to operate until the route locking time has expired.

3.02 TESTING REQUIREMENTS

A. General: Perform a visual inspection to verify that all equipment has been installed and is ready for test. Utilizing the arrangement drawings, verify that all wiring is in place and equipment tags are correct, and indicate as such with a green pencil on the approved Location Plans.

B. Static Testing: Verify that:

1. The grade and pedestrian crossing is wired according to the up-to-date approved Location Plans. Correct wiring shall be indicated as such by marking with a green pencil.
2. The grade and pedestrian crossing equipment is energized with the proper voltage and that the voltage remains within tolerance during operation. Record the voltage.
3. Pedestrian crossing activation and timers operate as designed. Record final timer settings.
4. Crossing lights operate properly and have been focused and aimed to provide the optimum visibility for pedestrians.
5. Bell voltages and volumes are within required tolerances. Coordinate volume with the Resident Engineer and adjust as necessary (e.g., low settings in noise sensitive areas). Measure and record voltage and volume settings.

C. Operational Testing: Refer to Section 34 42 95, Signal System Testing for requirements.

D. Dynamic Testing: Refer to Section 34 42 95, Signal System Testing for requirements.

E. Integration Testing: Refer to Section 34 42 95, Signal System Testing for requirements.

3.03 FIELD QUALITY CONTROL

A. Quality: The quality of the wayside signal system installation shall be ensured through the performance of tests and inspections made during the progress of this Contract and after completing the installation of equipment.

Perform field installation inspections to ensure that all equipment furnished under this Contract is installed in compliance with the technical specifications.

END OF SECTION 34 42 12

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SECTION 34 42 20

SIGNAL EXTERNAL WIRE AND CABLE

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes the requirements for exterior signal wire and cable to be furnished and installed in this Contract.

1.02 REFERENCED STANDARDS

A. American Railway Engineering and Maintenance-of Way-Association (AREMA):

1. Part 10.3.16 Recommended Design Criteria for Signal Cable, Non-Armored.
2. Part 10.3.17 Recommended Design Criteria for Signal Cable, Armored.
3. Part 10.3.19 Recommended Design Criteria for Ethylene-Propylene Rubber Insulation for Wire and Cable.
4. Part 10.3.21 Recommended Design Criteria for Polyethylene Insulation and Jacketing for Wire and Cable.
5. Part 10.4.1 Recommended Instructions for Wire and Cable Installation and Maintenance.
6. Part 14.1.1 Recommended Design Criteria and Functional/Operating Guidelines for Solder-less Crimp-Type Wire Terminals for Use in Wiring Signal Apparatus.
7. Part 14.1.5 Recommended Design Criteria for Molded Terminal Blocks.
8. Part 14.1.8 Recommended Design Criteria for Molded Blinding Post Type Terminal Block, Details and Assemblies.
9. Part 14.1.15 Recommended Design Criteria for Terminal Connectors, Details.

B. American Society for Testing and Materials (ASTM):

1. B3 Standard Specification for Soft or Annealed Copper Wire.
2. B33 Standard Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes.

C. Electronic Industries Association (EIA):

1. 359 Standard Colors for Color Identification and Coding.

D. Federal Railroad Administration (FRA), Code of Federal Regulations:

1. Part 234 Grade Crossing Signal System Safety.

2. Part 236 Rules, Standards, and Instruction Governing the Installation, Inspection, Maintenance, and Repair of Signal and Train Control Systems, Devices, and Applications

E. Institute of Electrical and Electronic Engineers (IEEE):

1. 383 Standard Type Test of Class IE Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations.

F. Insulated Cable Engineers Association (ICEA):

1. S-56-434 Polyolefin Insulated Communications Cables for Outdoor Use.

G. Department of Defense, Military Specifications (MIL):

1. MIL-C-24643 Cable and Cords, Electrical, Low Smoke, for Shipboard Use.

2. MIL-W-81044/12 Wire, Electric, Cross-Linked Polyalkene Insulated, Tin-Coated Copper, Light-weight, 600 V, 150 degrees C.

H. National Electrical Manufacturers Association (NEMA):

1. WC 5 Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.

2. WC 7 Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.

3. WC 57 Control Cables.

4. WC 70 Non-Shielded Power Cable 2000 V. or Less.

I. National Fire Protection Association (NFPA):

1. 70 National Electrical Code.

2. 262 Standard Method of Test for Fire and Smoke Characteristics of Wires and Cables.

1.03 QUALITY ASSURANCE

A. Qualifications:

1. All wire and cable manufacturers shall be approved by the Resident Engineer. The Contractor shall provide all data required for the Resident Engineer evaluation and shall make the arrangements for any required demonstrations and tests.

2. Qualifications shall be based on the following criteria:

a. Past Performance and Experience: The cable manufacturers must demonstrate previous successful experience in supplying wire and cable specified herein. A list of such installations shall be provided for each cable manufacturer to be considered.

b. Quality Assurance Program: The manufacturers of cables, in accordance with the requirements of these technical specifications, is required to have in place or implement, an effective quality assurance program adhering to the requirements of ISO 9001 to ensure purchase control performance. The Resident Engineer reserves the right to audit the manufacturer's facilities for conformance to the Contract. This may include, but is not limited to first article inspections, source inspections, and on-site surveys. Such compliance shall promote a thoroughly tested cable that will render long service life to the user. Prime concern must be focused on the necessary formal assurance requirements to ensure that cable failure cannot be attributed to actions or lack of actions by the manufacturer.

c. Technical Data: The Contractor shall provide full technical data that demonstrates compliance with the requirements of these technical specifications for each specified cable type the Contractor plans to supply.

d. Demonstration Tests: The Contractor shall make arrangements with the prospective cable manufacturers to perform demonstration tests as required by the Resident Engineer.

e. Sample Specimens: The Contractor shall, if requested, furnish to the Resident Engineer within 20 days after the Notice-to-Proceed, sample specimens in 4-foot lengths similar to that which the manufacturers propose to furnish for each type cable specified herein. The sample specimens shall remain the property of VTA.

f. The manufacturers shall certify compliance with the following warranty prior to selection:

1) The manufacturers warrant that the design, material, and workmanship incorporated in each item of cable shall be of the highest grade and consistent with the established, and generally accepted, standards for aerial and underground cable for transit AC power circuits; and that each such item and every part and component thereof shall comply with these technical specifications.

2) The manufacturers agree that this warranty shall commence with the acceptance of each item of the cable, whether the defect be patent or latent, and shall continue for a period of 1 year after final acceptance by VTA of all of the work under the contract.

3) The warranty covering any length of cable that shall be replaced by the manufacturers under the above conditions shall be reinstated for a period of 8 years effective as of the day when said replacement is effected. If the failure is found to be of major importance and affects any other item of cable, the reinstatement of the warranty shall then be extended to cover the item so affected as well, and shall start as of the date of such replacement. The warranty reinstatement provided for in this subparagraph 3) shall apply only to the first replacement or repair of any such item and, in the case of failure of major importance, to the first extension of the said warranty to said affected items.

4) The foregoing warranties are exclusive and in lieu of all other warranties written, oral, implied, or statutory (except as to title and freedom from lien). In no event shall the manufacturer be liable by reason of breach of warranty for special or consequential damages.

B. After Selection:

1. The Contractor shall monitor the manufacturers of the wire and cable to assure that the approved Quality Assurance Program is being closely adhered to and that the wire and cable is being manufactured in accordance with these technical specifications and the approved submittals.

2. Each finished wire and cable shall be traceable to the test date on file for each step in its manufacturing process.

3. Inspection:

    a. The Resident Engineer shall have the right to make such inspection and tests as necessary to determine if the cable meets the requirements of these technical specifications. The Resident Engineer shall have the right to reject cable that is defective in any respect.

    b. The Resident Engineer shall be given 15 days advance notice of the date the cable will be ready for final testing so that the Resident Engineer may witness the tests, if it so elects.

    c. Physical tests shall be made on samples selected at random at the place of production. Each test sample shall be taken from the accessible end of different reels. Each reel selected and the corresponding sample shall be identified. The number and lengths of samples shall be as specified under the individual tests. All applicable tests for the cable materials and cable construction specified shall be performed.

    d. The manufacturers shall provide, at the point of production, apparatus and labor for making any or all of the following tests under the supervision of the Resident Engineer to include:

        1) Conductor size and physical characteristics.

        2) Insulation HV and IR tests.

        3) Physical Dimension Tests.

        4) Special tests on materials in coverings.

        5) Final HV, IR, and conductor resistance tests on shipping reels.

    e. Certified electrical and physical test reports shall be furnished for the finished cables no later than the time of shipment. Each test document shall, in addition to the test results, indicate the date the tests were performed and the signature of the manufacturer's authorized representative.

    f. The Resident Engineer reserves the right to conduct those tests to provide further satisfaction that the cable is manufactured in accordance with the requirements of these technical specifications.

1.04 DELIVERY, STORAGE AND HANDLING

A. It shall be the Contractor's responsibility to replace any cable damaged, lost or stolen at no additional cost to the Contract.

B. Packing:

1. Products shall be so assembled or packed as to permit convenient handling and to protect against loss or damage during shipment.

2. Wire smaller than #4 AWG shall be shipped in cartons or in coils. When shipped in coils, the wire shall be securely bound with a layer of waterproof paper with each turn overlapping the other one-half its width if flat-edge paper is used, or one-third its width if folded-edge paper is used. Wires #4 AWG to #4/0 AWG, inclusive, shall be shipped on nonreturnable reels protected by fiberboard covering, bound with a steel strap or wire to prevent damage in transportation.

C. Marking:

1. Purchase Order, requisition and package number, name of Consignor, and name and address of Consignee, shall be plainly marked on outside of cartons, coils or reels.

2. Detail list of cartons, coils or reels shall be furnished for each shipment. Where carload shipments are made, routing and car identification shall be shown.

D. Handling:

1. Each shipment shall be inspected by the Contractor for evidence of damage upon delivery. Any damage such as reels loose from their blockings, damaged protective wrapping or lagging, or broken flanges shall be reported to the manufacturer, the carrier, and the Resident Engineer. VTA reserves the right to reject any cable damaged during the shipment, storage or handling process.

2. Cable reels shall be lifted with a lifting sling and spreader attached to a shaft through the wheel hubs, or with a forklift with tines supporting both reel heads. Lift pressure shall not, at any time, be placed on the cable.

3. The reels shall not be lifted by the top reel flange or dropped from any height. Lift truck forks shall not touch cable surfaces on the reel.

4. Reels shall be rolled only on flat surfaces cleared from any debris. Direction of rolling shall tighten the cable wind marked on the reel.

5. The factory-applied protective wrapping shall be left in place until cable installation. After partial installation of any cable from a reel, the remaining cable shall be resealed and the end tied off.

E. Storage:

1. Wires and cables shall be stored at the construction site on solid surfaces which adequately support the cable reels, but which shall be well drained and not allow accumulation of liquids, oils or chemicals. Reels shall not be laid flat. Outdoor storage time shall not exceed the manufacturer's recommendations.

2. The reels shall be aligned, and protection provided so as not to allow the reel flanges to damage other reels. Adequate aisles and barricades shall provide accessibility but prevent construction equipment from damaging the cable reels.

3. Suitable means, such as protective barriers, shall be provided to protect the cables from accidental damage during storage.

4. The Contractor, at no additional cost, shall provide security against theft and vandal damage to VTA.

1.05 SUBMITTALS

A. Cable Qualification Data: Submit cable qualification data, including the following:

1. Listing of Railroads and Transit Authority Customers: Provide a list of names of five railroads and transit properties to which the manufacturer has supplied cables similar to those required by these Specifications.

2. Cable Manufacturer's Quality Assurance Program.

3. Cable Manufacturer Qualification Report.

4. Insulation Qualification Test Documentation.

B. Cable Product Data: Submit cable product data, including the following:

1. Cable cut sheets or shop drawings.

2. Certificates of Compliance confirming that wire and cable supplied meets or exceeds the requirements of these Specifications.

3. Sample Specimens: The Contractor shall, if requested, furnish to the Resident Engineer within 20 days after the Notice-to-Proceed, sample specimens in 4-foot lengths similar to that which the manufacturers propose to furnish for each type cable specified herein. The sample specimens shall remain the property of VTA.

C. Cable Pre-Installation Documentation: Submit as part of the Installation Plan cable installation details, including the following:

1. Pulling layout including distances and tension calculations, for each section of installation.

2. Descriptions of pulling equipment and tension monitoring devices.

3. Procedures and materials for terminating the cable and preparing it for connection to the termination points.

4. Cable labeling including ID scheme, ID of each cable, and location of each tag.

5. Proposed installation procedures including:

   a. Hardware.

   b. Attachment.

   c. Routing.

   d. Conduit fill.

   e. Pull locations and equipment.

6. Proposed cable splicing procedures including:

   a. Material.

   b. Equipment.

   c. Testing.

7. Chronological plan for installing cable, including estimated time for each pull and plan for protecting cable on-reel and in slack loops during installation. Where staging of cable is required, identify details.

8. The Contractor shall submit one original plus ten copies of the projected loads and voltage drop calculations.

9. The Contractor shall furnish to the Resident Engineer one original plus ten copies of the cable manufacturer's instructions and procedures for potheading of each type underground cable to be furnished.

10. The manufacturer shall supply one original plus ten copies of instructions for splicing for each type of cable specified. The instructions shall be forwarded with the certified test results for each reel of cable. The instructions shall specify the exact nature of splicing materials to be employed, and the manner they are to be spliced.

11. Conduit and Cable Schedule.

12. Cable Entrance Sealant.

D. Cable Production Test Documentation: Submit cable production test documentation, including certified test results indicating clear indication of pass/fail criteria and cable performance.

E. Cable Post-Installation Documentation: Submit cable installation details, including the following:

1. Pull Tension Calculations (Post-Installation).

2. Update Conduit and Cable Schedule.

3. Conduit and Mandrel Report.

F. Cable Terminations: Submit product data and cable termination details, including the following:

1. Ring-type solder-less wire terminals.

2. Crimping tools.

3. Calibration certifications for crimping tools.

G. Test Reports. Submit test reports verifying compliance with testing requirements, per the requirements of Section 34 42 95, Signal System Testing.

H. The Resident Engineer reserves the right to request additional submittals than those described herein at no additional cost to the Contract.

1.06 MEASUREMENT AND PAYMENT

A. Measurement: Signal External Wire and Cable shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Signal External Wire and Cable shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in this Section, complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 MANUFACTURER QUALIFICATIONS SIGNAL WIRE AND CABLE

A. Manufacturer Experience:

1. Cable manufacturer shall have 10 years of documented experience in supplying cable to the railway or transit industry for use in installations similar to those required by this Contract, with a minimum 1,000,000 feet of cable installed.

2. Regardless of experience, provide documentation in the form of a qualification report, which identifies that the manufacturer meets the insulation qualification test requirements of these technical specifications.

B. Insulation Qualification Tests: Provide full documentation, including certified test results, that the wire and cable manufacturer has met the qualification tests identified herein for cable insulation. No insulation failure shall have occurred during these tests.

C. Production Tests: Production tests for cable shall be conducted per the requirements for tests in the AREMA Signal Manual, Part 10.3.16 for non-armored cables, Part 10.3.17 for armored cables, and as specified herein.

2.02 CABLE QUALIFICATION TESTS SIGNAL WIRE AND CABLE

A. Suitability of Insulation Material: The insulation shall be consistently uniform and established as suitable for service at potentials to 15 kV.

B. Voltage Aging Test:

1. The dielectric strength stability shall be demonstrated by voltage aging a test sample of a single conductor #14 AWG or larger wire with 80 mils or thicker insulation. The test sample shall be suitably constructed and finished, with any shield properly grounded, and with the cable ends suitably terminated. The cable shall be tested in free air with a minimum of 3 m (10 ft.) between terminals.

2. Referring to Table 1, one of the following voltage stresses shall have been applied to voltage-age the sample. No cable breakdown shall occur during the voltage aging test.

TABLE 1

Test Voltage (V/25 µm), 60 Hz	Aging Time
490	6 months
315	1 year
225	2 years
180	3 years
135	5 years

C. Step Breakdown Test: Upon successful completion of the voltage aging test, the same sample (excluding any 490 V/25 µm: 6-month samples) shall be subjected to a 60 Hz step-voltage test starting at the test voltage level used in the voltage-aging test. Increase in 10 kV steps for 5 minutes each until breakdown occurs. The sample shall withstand a minimum test voltage of 350 V/25 µm.

D. Thermal Aging Test: The insulation shall be tested in a circulating-air oven using 2.03 mm (80 mils) thick slabs, and shall have had an elongation not less than 50 percent after a minimum aging time of 25 hours at 135 degrees C (275 degrees F) and 100 hours at 121 degrees C (250 degrees F).

E. Moisture Resistance Test: To establish moisture-resistance characteristics, an insulated conductor sample, similar to that used for the Voltage aging test, shall be used. The test sample shall have had at least 3 m (10 ft.) immersed in water with any shield grounded and be tested at room temperature. The insulated conductor without any coverings over the insulation shall have been continuously energized with one of the voltage stresses applied with no failures occurring, as specified in Table 2.

TABLE 2

Test Voltage (V/25 µm), 60 Hz		Aging Time
325	for	2 months
280	for	3 months
240	for	4 months
200	for	6 months

2.03 GENERAL SIGNAL WIRE AND CABLE

A. Standard Assemblies:

1. Assembly of multi-conductor cables shall be per the AREMA Signal Manual, Part 10.3.16, for non-armored cables, and Part 10.3.17 for armored cables as modified herein.

2. One conductor in each layer shall be suitably marked to serve as a tracer. The assembly shall be capable of easy separation without damage to any of the conductors or loss of tracer identification.

3. Each conductor shall be numbered sequentially using surface printing at 150 mm (6 in.) intervals maximum. The numbering shall be so applied as to prevent the loss or transfer of identification during manufacture or installation. Numbering shall begin with #1 and continue in sequence without repetition until all conductors are identified.

4. A ripcord shall be included under the cushion layer or jacket but outside of any armor layer.

B. Duplex Assemblies:

1. Assembly of duplex assemblies shall be per the AREMA Signal Manual, Part 10.3.16, for non-armored cables as modified herein.

2. One conductor shall be suitably marked to serve as a tracer.

C. Identification:

1. Each length of cable shall be permanently identified on the outer jacket at regular intervals not to exceed 600 mm (24 in.). Print legend shall include manufacturer, year of manufacture, number of conductors, conductor size, and voltage rating.

2. The completed cable shall have sequentially numbered length markers on the outer jacket at regular intervals not to exceed 1.5 meters (5 feet). Accuracy of the markings shall be +/- 2 percent.

D. Reels:

1. Cable shall be placed and shipped on reels per the AREMA Signal Manual, Part 10.3.16, for non-armored cables, and Part 10.3.17, for armored cables, as modified herein.

2. Diameter of the drum shall be at least 14 times the cable diameter to prevent damage to the cable.

3. Each reel shall be marked with legible weather resistant information on the outside flange including, the manufacturer's name, purchase requisition number, lengths of each section of cable, number of conductors, gauge of conductors, and the name and address of the consignee.

4. An arrow shall be painted on one flange of each reel pointing the opposite direction from the outer end of the cable with the words "roll this way."

E. Grounding Materials: Shield grounding materials shall be provided, if shielding is required by the signal design.

2.04 EXTERIOR SIGNAL WIRE AND CABLE

A. Definition: Exterior signal wire and cable is defined as all signal cable installed external to signal equipment housing/room/cases. All signal wire and cable shall be exterior except where interior wire or cable is specifically approved.

B. Application: At a minimum, unless specified or approved otherwise, the types of cable indicated on the double line schematics shall be utilized. Adjust final conductor and cable sizes to account for voltage line loss to provide a complete operational system, and to meet spare conductor requirements.

C. Service Life: Exterior signal wire and cable shall be of rugged construction and shall have insulation and jacket materials designed for a 40-year minimum service life.

D. Voltage Rating: Exterior signal wire and cable shall be rated for 600 V minimum.

E. Conductors: Conductors shall be solid, soft or annealed copper, and coated in accordance with ASTM B33 for tin-coated conductors or B189 for lead-coated or lead-alloy-coated conductors. No factory splices or brazes shall be made in solid conductors after final drawing. Minimum conductor size for all conductors in exterior wire and cable shall be #14 AWG, unless specified or indicated otherwise.

F. Spare Requirements: Upon final adjustment of cable sizing, ensure that a minimum 10 percent spare conductors, with a minimum of two conductors in any cable (track circuit, signal power, and TWC cable excepted), have been provided.

G. Insulation:

1. Conductor insulation for all wire and cable shall be vulcanized, ethylene propylene rubber (EPR) compound meeting the electrical and physical requirements of AREMA, Part 10.3.16 for non-armored signal cable, and Part 10.3.17 for armored signal cable. Insulation shall have moisture

and heat resistance characteristics suitable for continuous operation at 90 degrees C (194 degrees F) in wet and dry locations, above and below ground, in trays, troughs, conduits, and duct banks.

2. The insulation shall be applied concentrically and adhere tightly to the conductor surface but be free stripping and leave the conductor clean and ready for use.

3. Conductor insulation thickness for exterior wire and cable shall meet AREMA Signal Manual requirements for Class A insulation thickness. The minimum thickness of the insulation at any point shall not be less than 90 percent of the thickness specified by the AREMA Signal Manual.

H. Jacket:

1. Single conductor and multiple conductor cables shall be provided with an outer jacket. Unless otherwise specified, jacket shall be of extruded black low density, high molecular weight polyethylene material meeting the electrical and physical requirements of AREMA Signal Manual, Part 10.3.21.

2. Jacket thickness on single and multiple conductor cables shall meet AREMA Signal Manual, Part 10.3.16. The minimum thickness of the jacket at any point shall not be less than 90 percent of the thickness specified by the AREMA Signal Manual.

2.05 TERMINALS

A. General: Supply terminals for termination of wires and cables as required in various sections of these technical specifications. Terminals shall be provided in the signal housing/room/case, and all junction boxes, unless specified otherwise.

B. Terminal Blocks:

1. Terminal blocks shall meet the requirements of AREMA Signal Manual, Parts 14.1.5, and 14.1.8.

2. Furnish terminal blocks complete with all screws, nuts, washers, and test links necessary for installation and wire termination. Nuts and washers shall meet the requirements of AREMA Signal Manual, Part 14.1.11.

3. Terminal binding posts shall be suitable for railway signaling circuits, and shall meet the requirements of AREMA Signal Manual, Part 14.1.10.

C. Hardware:

1. Test links shall be of the straight, insulated, gold-nut type, to allow opening of circuits for testing without disconnecting terminated wires. Test links shall meet the requirements of AREMA Signal Manual, Part 14.1.15. Provide lock nuts to lock test link nuts in-place.

2. All AREMA type terminal posts located on entrance racks which terminate a circuit with 50 V or greater shall be fitted with individual, fire-resistant protective insulators. Insulator shall be installed after all wire terminations and connections have been made.

PART 3 – EXECUTION

3.01 APPLICATION

A. General: At a minimum, unless specified or approved otherwise, provide cable as indicated in the Contract Drawings. Adjust final conductor and cable sizes, and routing, to account for voltage line loss to provide a complete operational system, and to meet spare conductor requirements.

3.02 INSTALLATION

A. Installation Plan:

1. Develop a written cable installation procedure and check-off list for approval prior to cable installation. Base the procedure on the review of the conduit plans and field site survey, and include a cable plan and installation information for each cable pull.

2. The installation plan shall include proper procedures for feeding cable into conduit, to maintain proper bend radii, and to minimize friction.

3. When pulling cable through conduit with existing cable, the existing cable shall be disconnected and pulled back, then pulled through the conduit with the new cable. Contractor shall be responsible for any testing of cable or equipment affected by the pull.

4. Identify staging work associated with installation and removal of cable. Existing signal systems shall remain operational at all times, with the exception of approved shut-down periods.

5. Install cable per the approved installation and cable plans.

B. General:

1. Installation of signal wire and cable shall conform to AREMA Signal Manual Part 10.4.1 and the manufacturer’s installation instructions and recommendations.

2. The installation of power wire and cable shall conform to applicable sections of NFPA 70 and the requirements as specified herein.

3. Exposed wire and cable will not be permitted along the wayside, unless pre-approved (e.g., crossbonding).

4. Contractor shall be responsible for verifying the required cable length for each cable run prior to installation. Civil stationing appearing on contract drawings may be used for defining locations and estimating cable lengths. However, no existing drawings shall be used to determine final lengths and cuts. Actual lengths shall be determined by making on-site inspections and measurements.

5. Wires and cable shall be continuous without splices between junction boxes, terminals, pull boxes, manholes and hand holes.

6. Cable shall not be bent to a radius less than the greater of 12 times the diameter of the cable or the manufacturers' recommended minimum bending radius, during installation or as finally installed.

7. Install wire and cables in conduits, cableways, and troughs after all conduits, cableways, and troughs are in place, all related work is completed, and the area cleared for a safe working condition. Cables shall be laid into cableways and troughs, rather than pulled wherever possible.

8. Cable shall be laid with a minimum amount of crossover, shall be secured at least every 3 feet and shall not be pulled or formed tightly around bends. Conduits for cables entering or leaving trays shall be rigidly attached and supported at their ends by suitable brackets and conduit straps.

9. Cable shall be protected immediately after installation and prior to terminating or splicing. All cables shall be tagged and labeled immediately after installation. Cables shall be tagged at their termination points. In addition, all cables shall be tagged within Signal Rooms, Signal Shelters, manholes, handholes, housings, etc. and on each side of any barrier the cable passes through. Cables shall also be tagged at aerial exits from conduit risers. Re-seal cable ends when a length is cut from a reel.

10. Install grommets or use other methods to protect incoming cables to houses/rooms/cases, and other equipment, from abrasion. Where cables are routed vertically, provide proper support as necessary to relieve strain. In no case shall the weight of cables be allowed to pull against cable terminations.

11. All exposed wires and cables entering or leaving signal equipment housing/room/cases, junction boxes, and cable transition points shall be protected from abrasion. Chase nipples and/or split ring plastic grommets shall be provided in drilled or punched openings in equipment housing/room/cases and junction boxes.

12. All cable entrance openings shall be sealed with either a compression type fitting or pliable sealing compound after the cable is in place. Sealing compound shall be used to seal the area around cable where the cable emerges from the end of a conduit or pipe. All spare conduits shall be sealed or plugged in an approved manner. Cable openings within the substation and signal housing floors and/or walls shall be sealed with an approved fire sealant per ASTM E814.

13. Where cables leave conduits, the ends of the conduit shall be fitted with end bells to prevent damage to the cable.

14. Provide sufficient slack in installation of wire and cable for relief of stress due to vibration and to allow for 3 re-terminations of each conductor without re-servicing or re-potheading the wire or cable. Contractor shall provide service loops sufficient for the maintenance and free movement of attached electrical equipment.

15. Where multi-conductor cables are to be terminated in an enclosure, the outer jacket and shield (where applicable) shall be carefully removed to a point close to the cable entrance. At the end of the cable sheath or covering, apply two layers of an approved electrical plastic tape. Conductors shall then be neatly arranged, bundled, and tied approximately every 3 inches. These bundles shall be routed vertically to a point higher than the top terminal post and then turned and terminated from the top terminal down in reverse wire number order (highest number at the top). Observe all wire bend radius restrictions. Cable connections and splices shall be made in strict accordance with the manufacturer's instructions.

16. Cables with bronze tape shield shall have the shield grounded on one end of each cable run. Submit a shield grounding plan for approval. Shield grounding materials shall be provided per the approved grounding plan.

17. Open wiring on equipment racks shall be neatly arranged, bundled, and tied approximately every 3 inches with nylon straps. All straps shall be of the same color.

18. Remaining cable tails and reels over 60 m (200 ft.) may shall be delivered to VTA at the discretion of the Resident Engineer. All cable tails and reels not delivered to VTA shall be disposed of by the Contractor.

19. Where 120 Vac power cable is installed in the CSD from one location to another, via manholes, pullboxes, vaults, provide physical separation required to minimize EMI impacts to other systems. Provide power cable in conduit, or provide physical enclosures if necessary.

20. Contractor shall arrange the cables to allow free access to all existing cables for maintenance. Cables shall be placed in conduits identified to the Contractor by the contract drawings.

21. Cables shall be installed with freedom of horizontal movement to accommodate expansion and contraction of the cables in the conduits.

22. The Contractor shall provide appropriate special protection for cables in areas where the cables are unavoidably exposed to hazardous conditions such as vibration or sharp corners on equipment. Cables damaged due to Contractor's neglect while installing cables shall be replaced by the Contractor at no additional cost to the Contract.

23. When pulling cable through conduit with existing cable, the existing cable shall be disconnected and pulled back, then pulled through the conduit with the new cable. Contractor shall be responsible for any testing of cable or equipment affected by the pull.

24. Cable installation in conduit shall not exceed 40 percent fill per conduit, unless otherwise allowed by the Resident Engineer.

25. Cables installed in manholes shall be properly constrained and fastened to the walls of the manhole in accordance with the approved installation drawings.

26. Notification: Notify the Resident Engineer 48 hours prior to any cable installation activities.

C. Ductbank:

1. Perform extension of conduits and minor modifications or changes to the duct system to support signal and communications requirements, at no cost to VTA. Coordinate signal and communications conduit utilization to minimize cable crossovers in pullboxes and to provide a professional finished product.

2. Provide additional conduit as required to access signal equipment enclosures or apparatus, including any conduit required for installation of track circuit connections, TWC loops, power switch machine, and CSD interface to housing foundation.

3. Cable installed in conduit, regardless of length, shall not exceed the maximum fill recommendations of the manufacturer, unless otherwise approved.

4. Provide any installation hardware necessary to route, support, terminate, or protect cable.

5. Ensure that conduits are dry before installation of cable and use a pulling compound or lubricant approved by the manufacturer, which is compatible with the cable. Utilize the lubricant in the quantity recommended by the lubricant supplier and shall be applied in a manner that ensures that the cable is lubricated throughout the entire length being installed. The lubricant shall be non-hygroscopic and vermin-proof.

6. When pulling cable through conduit with existing cable, the existing cable shall be disconnected and pulled back, then pulled through the conduit with the new cable. Contractor shall be responsible for any testing of cable or equipment affected by the pull.

7. Cable made expressly for the purpose of direct burial shall not be installed in conduit.

8. Inspect manholes and pullboxes for structural correctness and cleanliness prior to accepting an area as suitable for installation to proceed.

9. Remove covers as required for installing cable. Covers shall be placed along right of way so that movement of trains or construction vehicles is not impeded. Care should be taken to prevent damage to the covers. Contractor shall be responsible for any damage to cover during cable installation. If any damage is evident prior to cable installation, it should be brought to the attention of the Resident Engineer.

10. Install manhole (and pullbox, where applicable) cable racks prior to installing cable.

11. De-water and remove dirt and trash from manholes and pullboxes prior to and during installation of cable.

12. When conduit is being extended by the Contractor to complete the installation, mandrel each conduit and document results on the Conduit and Mandrel Report.

13. Cables installed in manholes shall not interfere with the future use of or access to unused conduit.

D. Cable Pulling:

1. Calculations shall be made to estimate pulling tensions for cable pulls, which require the use of pulling apparatus. These tensions shall be calculated in both directions to determine which will result in less stress on the cable. The direction requiring lower tension shall be used where possible. Indicate how each installation will be completed within the limitations and recommendations of the manufacturer and these technical specifications. All installation calculations shall be submitted to the Resident Engineer prior to the start of cable installation. Tension calculations need not be provided for short sections of cable, which will be installed by hand pulling.

2. Apparatus to be used in pulling-in cable shall be in good working order and shall be demonstrated to the Resident Engineer for approval. Pulling apparatus shall be provided with a smooth variable speed control. A dynamometer shall be used for all cable installations that are not installed by hand. The dynamometer used for cable pulling shall bear a record of calibration against certified standards indicating calibration within the last 180 days.

3. Two-way communication between the pulling and feed end of each pull shall be established before and maintained during the installation.

4. Reels shall be stripped of all nails in outside edges of reel heads before pulling of cable, and shall be conveniently located for feeding cable into the conduit without excessive bending or possible injury to cable by abrasion on sides of pull boxes where pull boxes are required. Reels shall be jacked to clear ground level by at least 150 mm (6 in.) before pulling cable.

5. Cable reels shall be carefully handled to avoid injury to persons or cables. Movement of reels on loading skids or sloping grades shall be controlled by use of a snub line or wedge. Reels shall always be blocked after positioning.

6. Cable shall be pulled into conduits with the use of a pulling eye approved by the Engineer. Pulling ropes shall be attached to the pulling eye with ball-bearing swivels to prevent twisting of cable during pulling.

7. Cable shall be pulled into conduits under moderate tension. Manufacturer's recommended maximum pulling tension shall not be exceeded at any time. Before pulling any cable into

conduits, the Contractor shall first consult with the Engineer as to methods and locations of cable pulling.

8. Personnel shall be stationed between the reel and the conduit entrance during pulling operations to inspect control and direct the passage of cable. The conduit mouth shall be equipped with conduit shields to prevent chafing of the cable. Use UL-listed lubricant and provide suitable installation equipment to prevent cutting and abrasion of wire during the pulling of feeders.

9. Avoid using any lubricant that may be injurious to the materials of the wires and cables to be installed. Provide installation procedure as recommended by the cable manufacturer, and approved by Resident Engineer.

10. Cable shall not be allowed to chafe on the ground, in manholes or handhole edges, or any sharp surfaces during pulling. Flexible pulling tubes shall be provided to guide and protect the cable, where necessary.

11. Pulling shall be done at a constant velocity, not less than 15 ft./min nor more than 50 ft./min, unless otherwise recommended by the cable manufacturer. The pull shall not be stopped once started unless absolutely necessary.

12. Measure, record, and submit the dynamometer reading and the actual pulling tension for each pull along with any conversion calculations and a copy of the certificate of calibration for each instrument. These cable installation records shall be filled out in the field and signed and dated by the installation/test engineer. Contractor shall submit the original forms to the Resident Engineer.

13. After pulling, the tension end of the cable damaged in the pulling process shall be cut off.

E. Signal Wire Splices and Terminations:

1. Terminations for wire and cable shall conform to AREMA Signal Manual Part 10.4.1.

2. Splices will not be permitted in signal wires or cables unless pre-approved by the Resident Engineer, or otherwise specified. If approved, splices shall conform to AREMA Signal Manual Part 10.4.1. Wires and cables shall be continuous between all designed termination points. If the signal wire or cable cannot be installed continuously between designed termination points, install an intermediate enclosure for termination at no additional cost to VTA. Cable for track circuits, at the rail end, shall not be terminated on blocks, rather a service loop shall be installed in a pullbox, and the cable run directly to the rails. Refer to Section 34 42 11, Track Circuits for additional details.

3. For stranded conductors, terminations shall be made using ring-type solder-less wire terminals on wire terminal posts in conformance with AREMA Signal Manual, Part 14.1.1 and Part 14.1.5. An approved ratchet-type, calibrated, crimping tool shall be used to apply ring terminals to conductors which applies proper, uniform pressure to the ring terminal, and which shall not release until proper pressure has been applied.

4. For solid conductors, terminations shall be made by forming the conductor into an eye which fits snugly on the terminal post. Wire shall not be nicked or twisted when forming eyes. Formed wire eyes shall be placed on terminals, between terminal washers, in a manner to ensure closing of the eye when terminal nuts are tightened. Wire strippers, made expressly for the purpose of removing insulation from wire, shall be used. Contractor shall prevent cuts and nicks in the wire. Utility and pocket knives shall not be used for stripping insulation or cable jackets.

5. All wires and cables shall be terminated in a junction box or signal housing/room/case, unless specified otherwise. External cable conductors and internal conductors shall be terminated on separate terminal posts connected by concave test nut terminal connectors in conformance with AREMA Signal Manual, Part 14.1.15. Signal cable entering and then leaving the housing/room/case or a junction box shall be separately terminated and cross-connected with concave test nut terminal connectors.

6. All entrance rack terminations shall be on an approved terminal board in the signal housing/room/case and shall be accessible from the front.

7. All spare conductors shall be terminated on spare terminal posts, and in consecutive wire number order in the same fashion and location as active conductors.

8. If wire and cable terminations are not made immediately after installation, ends of cable shall be sealed as recommended by the manufacturer to prevent the entrance of moisture.

F. Track Circuits:

1. Pull track circuit cable through the pullbox direct to the rail termination locations. Provide a service loop in the pullbox with sufficient slack for three re-terminations.

2. If a solid conductor wire is approved and utilized for track circuits, provide a splice in the pullbox to transition from solid wire to the bond strand wire required to cad weld to the rail. Splice shall be either a Burndy type connector or a butt splice, soldered to the solid conductor and crimped to the stranded connector. Epoxy fill and tape all splices.

G. TWC Cable:

1. Install TWC cable and loop converter box in the pullbox. Provide a service loop with sufficient slack for three re-terminations.

H. Crossbonds: Install impedance bond negative return cable, where indicated on the Contract Drawings, per the requirements of Section 34 42 24, Rail Bonding.

I. Tagging: Tag signal wire and cable per the requirements of Section 34 42 22, Signal Internal Wiring.

3.03 SIGNAL CABLE TESTING

A. Pre-Installation Cable Test: Inspect and test cable reels prior to installation of cable. The test shall ensure that:

1. The exterior of the cable is free from nicks, gouges, and damage insofar as the cable can be inspected.

2. Insulation resistance between all conductors, as well as between conductors and shield or armor, if applicable, meets specified values.

3. Continuity for each conductor is within satisfactory limits.

4. The cable is of the type and configuration specified for its intended purpose.

B. Post-Installation Cable Test: Inspect and test each individual cable, conductor, and splice (when approved) after cable installation has been completed, and prior to the commencement of wayside testing. The test shall ensure that:

1. The exposed portion of either end of the cable shows no obvious signs of damage to the exterior.

2. The cable has been properly and uniformly installed and supported, and adequate slack has been provided to prevent strain on the cable termination points.

3. The cable shows an adequate insulation resistance [at least 100 Mohm tested with 1 kVdc] to ground, and between each conductor and all other conductors. Both ends of each conductor shall be isolated when performing these tests.

4. Continuity for each conductor, and the shield, where applicable, is within satisfactory limits. Document results on the Record of Insulation Resistance Tests form.

5. Insulation resistance between all conductors, as well as between conductors and shield, meets specified values. Document results on the Record of Insulation Resistance Tests form.

6. Wire, cable and terminal board (entrance rack) tags are in place and have been verified.

7. Each cable and conductor size is of the proper size, voltage rating, and type required for the specific installation, and agrees with all applicable arrangement plans. Correct cable designations shall be indicated on the approved Location Plans by marking with a green pencil.

8. Cable destinations, as indicated on all applicable arrangement plans, for both ends of the cable agree with actual cable destinations. This shall include any intermediate termination locations. Correct cable destinations shall be indicated on the approved Location Plans by marking with a green pencil.

9. Each conductor termination has utilized the proper size and type of terminal and has been properly crimped.

10. The cable shield, if applicable, has been grounded at the proper end of the cable.

C. Operational Testing: Refer to Section 34 42 95, Signal System Testing for requirements.

D. Dynamic Testing: Refer to Section 34 42 95, Signal System Testing for requirements.

E. Integration Testing: Refer to Section 34 42 95, Signal System Testing for requirements.

3.04 FIELD QUALITY CONTROL

A. Quality: The quality of the wayside signal system installation shall be ensured through the performance of tests and inspections made during the progress of this Contract and after completing the installation of equipment. Perform field installation inspections to ensure that all equipment furnished under this Contract is installed in compliance with the technical specifications.

END OF SECTION 34 42 20

SECTION 34 42 22

SIGNAL INTERNAL WIRING

PART 1 – GENERAL

1.01 SUMMARY

A. Description

1. Furnish and install wire and cable in the wayside cases and in enclosures where it will not be exposed to the elements. Intra-rack and rack-to-rack wire and cable shall be in accordance with the requirements of this Section.

2. Stranded wire, including individual conductors of multi-conductor cables covered by this Section, shall be per Military Specification MIL-W-22759 and the specifications contained herein.

3. Multi-conductor cable covered by this Section shall be per the multi-conductor cable specifications contained herein.

4. Where there is a difference between the requirements of this Section and other specifications referenced herein, the requirements of this Section shall govern.

1.02 REFERENCED STANDARDS

A. American Railway Engineering and Maintenance-of Way-Association (AREMA):

1. Part 10.4.1 Recommended Instructions for Wire and Cable Installation and Maintenance.

2. Part 14.1.1 Recommended Design Criteria and Functional/Operating Guidelines for Solder-less Crimp-Type Wire Terminals for Use in Wiring Signal Apparatus.

3. Part 14.1.5 Recommended Design Criteria for Molded Terminal Blocks.

4. Part 14.1.6 Recommended Design Criteria for Multiple Unit Binding Post Type Terminal Block, Details and Assemblies.

5. Part 14.1.8 Recommended Design Criteria for Molded Binding Post Type Terminal Block, Details and Assemblies.

C. American Society for Testing and Materials (ASTM):

1. B3 Standard Specification for Soft or Annealed Copper Wire.

2. B33 Standard Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes.

3. B189 Standard Specification for Lead-Coated and Lead-Alloy-Coated Soft Copper Wire for Electrical Purposes.

D. Institute of Electrical and Electronic Engineers (IEEE):

1. 383 Standard Type Test of Class IE Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations.

E. Department of Defense, Military Specifications (MIL):

1. MIL- W-22759 Wire, Electrical, Flouropolymer-Insulated, Copper or Copper alloy.

1.03 SUBMITTALS

The Contractor shall submit the following for approval.

A. Complete technical data verifying that the internal wire and cable which the Contractor proposes to furnish in compliance with the requirements of this Section.

B. Sample Specimens: The Contractor shall, if requested, furnish to the Resident Engineer within 20 days after the Notice-to-Proceed, sample specimens of the proposed wire and cables in 4 foot lengths similar to that which the manufacturers propose to furnish for each type cable specified herein. The sample specimens shall remain the property of VTA.

C. Certified test reports on finished cable.

A letter from each proposed wire and cable manufacturer, on the manufacturer’s letterhead, guaranteeing that:

1. The proposed manufacturer has a copy of Specification Section 34 42 22, Signal Internal Wiring.

2. The proposed manufacturer will fully comply with all of requirements of the Specification.

3. The proposed manufacturer will fully comply with all of requirements of the Specification.

D. Factory and field test plans, procedures, and reports in accordance with Section 34 42 95, Signal System Testing.

E. Quality Assurance Program of the wire and cable manufacturers.

F. Test Reports. Submit test reports verifying compliance with testing requirements, per the requirements of Section 34 42 95, Signal System Testing.

1.04 QUALITY ASSURANCE/QUALITY CONTROL

A. All Work covered by this Section shall be accomplished in compliance with a Quality Assurance Program submitted to and approved by VTA.

B. All wire and cable manufacturers shall be approved by the Resident Engineer. The Contractor shall provide all data required for Resident Engineer evaluation and shall make the arrangements for any required demonstrations and tests.

C. Test multi-conductor cables to verify conformance with the requirements of this Section as follows:

1. Test individual conductors per the requirements specified herein for Stranded Wire for General Use, prior to cable assembly.

2. Place finished cables in water at room temperature. After 48 hours immersion and while still immersed, test conductors for breakdown at a voltage of 2,500 V (rms) for 5 minutes.

3. Flame test samples of finished cable fabricated from each batch of cable outer sheath material per IEEE Standard 383.

1.05 MEASUREMENT AND PAYMENT

A. Full compensation for providing Signal Internal Wiring shall be considered as included in the bid item for Signal Equipment Housings and no additional compensation will be allowed therefore.

PART 2 – PRODUCTS

2.01 MATERIALS

A. General Requirements

1. The requirements for wire described herein shall consist of this Specification and the issue in effect of Military Specification MIL-W-22759. Where there is a discrepancy between this Specification and the requirements of the applicable Military Specification, the requirements of this Specification shall govern. The requirements of this Specification shall also be used where the Military Specification refers to the requirements of the applicable military Specification sheet.

2. Furnish and install internal stranded wire subject to the following requirements:

   a) Conductor - Stranded Soft Annealed Copper per ASTM B3.

   b) Coating - Tin or lead per ASTM B33 or B189.

   c) Insulation - ETFE – Ethylene-Tetrafluoroethylene or E-CTFE – Ethylene-Chlorotrifluorethylene per MIL-W-22759 and Table D below.

   d) Construction - Per Table A below.

   e) Performance - Per Tables B and C below.

TABLE A
CONSTRUCTION DETAILS

Wire Size (AWG)	Conductor Stranding (Strands x Size)	Max. Diameter Stranded Conductor (Inches)	Conductor Resistance Max at 20°C (Ohms/1000 Feet)
22	19 x 34	.033	16.2
20	19 x 32	.041	9.88
18	19 x 30	.051	6.23
16	19 x 29	.058	4.81
14	19 x 27	.073	3.06
12	37 x 28	.090	2.02
10	37 x 26	.114	1.26
8	133 x 29	.173	0.701

TABLE B
PERFORMANCE DETAILS - ABRASION RESISTANCE

Wire Size (AWG)	Min. Resistance (Inches of Tape)	Weight Support Bracket	Weight (Pounds)	Tension Load (Pounds)
22	26	A	1.0	1.0
20	26	A	1.0	1.0
18	27	A	1.0	1.0
16	28	A	1.0	2.0
14	19	B	3.0	2.0
12	29	B	3.0	2.0
10	36	B	3.0	3.0
8	35	B	3.0	3.0

TABLE C
PERFORMANCE DETAILS -- BEND TESTING

Wire Size (AWG)	Mandrel Diameter Life Cycle	(Inches Max) Cold Bend	Test Load Life Cycle	(Pounds) Cold Bend
22	¾	1	1.5	3.0
20	¾	1	2.0	4.0
18	1	1 – 1/4	2.0	4.0
16	1	1 – 1/4	2.0	5.0
14	1 – ¼	2	2.0	5.0
12	2	2	2.0	5.0
10	3	3	2.0	5.0
8	3	4	3.0	6.0

TABLE D
ETHYLENE-TETRAFLUOROETHYLENE OR ETHYLENE-CHOLOROTRIFLUORETHYLENE PHYSICAL AND ELECTRICAL PROPERTIES

Type of Insulation	ETFE or E-CTFE
Military Specification	MIL-W-22759
Nominal Wall Thickness Size #24 – #12 AWG	*15 mils
Nominal Wall Thickness Size #10 – #6 AWG	*20 mils
Temperature Rating	150°C
Blocking (Qualification only)	200°C
Color	Black
Flammability	Pass

Type of Insulation	**ETFE or E-CTFE**	
Identification	30 inch intervals (maximum)	
Identification, Striping	125 Cycles (250 Strokes) or Printing Durability	
Life Cycle	Oven temp. 200°C for 168 hrs	
Dielectric Test	2200 V (rms), 60 Hz	
Accelerated Aging	7 hrs at 210°C (Quality Conformance Test, Group II; Procedure as in Life Cycle Test) Physical Properties of Insulation	
Tensile Strength PSI (min.)	5,000	
Elongation percent (min.)	125	
Chemical Resistance	Test not required	
Shrinkage at 200° +/- 2°C, inches (max.)	0.125	
Smoke	200°C	
Thermal Shock	Test not required	
Cold Bend	-65°C	
Wrap Test (Size #20 AWG wire)	2 hrs at 200°C No cracks	Mandrel diameter 0.125 inches
Dynamic Cut Through Pounds (min.) at 23°C with Size #20 AWG	90	
Wicking Abrasion Resistance after Immersion	Same as initial	
Lamination Sealing	NA	
Polyimide Cure Test	NA	
Resin Coating Durability	NA	
Humidity Resistance	IR after exposure shall meet initial requirements	
Voltage Rating	600 V RMS	
Impulse Dielectric Test (100%)	8 kV Peak	
Insulation Resistance	5000 megohms per 1000 feet (minimum)	
Spark Test	Test not required	
Surface Resistance, Megohms/inch (min) Initial and Final	500	
Wet Dielectric Test volts (rms)	2500	

** The minimum thickness of the insulation at any point of the cross section of the insulated conductors shall not be less than 90%.*

B. Special Requirements for Stranded Wire

1. Flame Spread.

Flame spread is defined as the propagation of flame under given burning conditions. Flame spread tests are referred to as VW-1 test in UL 1581. It is required that the wire used not be judged as capable of conveying flame along its length.

2. Mark each stranded wire with the following information repeated at intervals no greater than 12 inches.

   a) Manufacturer's name.

   b) Year in which wire is manufactured.

   c) Size of conductor.

   d) Type of insulation.

   e) The identifying markings shall be permanent and easily readable and understandable.

   f) Stranded wires used in multi-conductor cable shall be numbered or color coded in addition to the basic four-part identification.

C. Internal Multi-Conductor Cable

1. Fabricate the outer jacket of Thermoplastic Rubber (TPR) rubber to comply with the requirements of IEEE Standard No. 383, latest revision. The jacket shall be stabilized for outdoor exposure. The outer sheath shall have a nominal thickness in accordance with ICEA S-68-516, Table 4-16. The barrier tape shall be 0.005 inch thick, with a minimum 25 percent overlap. The individual conductors shall be sized to meet 150 percent of the load requirements, but shall be no smaller than #20 AWG, stranded.

2. Make cables by assembling the individual, or twisted pairs, of insulated wires into a tight, cylindrical form. Assemble individual or twisted pairs helically and with adjacent layers wound in opposite directions.

3. The makeup of multi-conductor cables specified by this Section shall not exceed 50 conductors. Individual wires of multi-conductor cables shall be numbered consecutively at intervals of 12 inches.

4. Multi-conductor cables shall have at least 10 percent spare conductors, but not less than two spare conductors. Spare conductors are to be terminated.

5. Mark the cable outer sheath with the following information repeated at intervals no greater than 36 inches.

   a) Manufacturer's name.

   b) Year of cable manufacture.

   c) Number and size of conductors.

   d) Type of insulation in wires.

   e) Type of outer sheath insulation.

   f) Voltage rating.

6. The identifying markings shall be permanent and shall be easily readable and understandable.

PART 3 – EXECUTION

3.01 INSTALLATION

A. General

Install internal wire and cable in accordance with the applicable requirements of AREMA 2011 Communication and Signals Manual Part 10.4.1, Recommended Instructions for Wire and Cable Installation and Maintenance and as specified herein.

1. Install wires and cables in a neat, workmanlike manner. Cables in trays or in troughs shall be laid herein and not pulled into same. Install cables with a minimum amount of cross-over in the trays and troughs and do not pull tightly around bends. Exposed wires and cables entering or leaving equipment racks or housings shall be protected from abrasion by sharp metallic edges.

2. Provide and install nylon straps for bundling and cabling of conductors where two or more single conductors are exposed in internal rack bundles, cable trays or cable troughs, or whenever wires are to be bundled. Do not use tape for this purpose. Install straps at intervals of 2 feet, or shorter if required to maintain good workmanship standards along the cable run. Train wires of multi-conductor cables exposed by the stripping of the cable jacket for terminations in a neat, workmanlike manner and tied approximately every three inches with nylon strips.

3. There shall be no point-to-point redundancy of wires for increased current capacity.

4. Use single conductor #14 AWG stranded wire for interconnecting signal junction boxes and lamp compartments and other miscellaneous equipment.

5. Provide strain relief where needed.

6. Fully protect wires and cables against contact with any surface other than that designated specifically to support or protect them.

7. Lay wires and cables in place with sufficient slack at the bends so that wires and cables will clear the inside bend surface of the wireway, thereby preventing crushing the insulation.

8. Wire and cable shall be free of kinks and insulation damage. Wire installation shall not be subject to accumulations of moisture or foreign matter.

9. Wire and cable dress shall allow for sufficient slack to provide for shock and vibration induced movements, equipment shifting, alignment, cover removal, and component replacement.

10. Tie wiring and cabling dress in harness arrangements with a high strength approved dielectric wire tie designed not to invade the wire insulation. Trim and locate wires and cable ties to eliminate any hazard to personnel from sharp edges.

11. Wires and cables shall be free from metal edges, bolt heads, and other interference points, and shall have electrical clearance from the covers, regardless of the insulation properties of covers or doors.

B. Wire and/or cable splices shall not be used. All wire and cables shall be terminated on AAR terminals, in above-ground signal cases, signal houses, signal rooms, impedance bonds, or junction boxes adjacent to signals, track connections, or switch machines.

C. Plug connectors shall not be used for vital wiring.

D. Terminations

1. All wires and cables shall be trained into final position while observing minimum bending radii. Slack shall be provided at all terminals in an amount sufficient for two re-terminations.

2. Wire and cables where connected directly to signal equipment shall be of sufficient length to allow access for removal and inspection of equipment. Wires and cables shall be continuous, without splices, between terminals within a housing and enclosure or piece of equipment.

3. Termination work shall be conducted under clean and dry conditions.

4. All cable conductors, including spare conductors, provided over and above the Contract requirements, shall be terminated on multiple unit AAR terminal blocks in accordance with AREMA 2011 Communications and Signals Manual Part 14.1.6, Recommended Design Criteria for Multiple Unit Binding Post Type Terminal Block. Track wires and cables may be terminated on lightning arresters.

5. Stranded wire, compression-type, insulated wire terminals in accordance with AREMA 2011 Communications and Signals Manual Part 14.1.1, Recommended Design Criteria and Functional/Operating Guidelines for Solderless Crimp-Type Wire Terminals for use in Wiring Signal Apparatus, shall be used. The wire terminals shall be installed only with tools and techniques recommended by the terminal manufacturer and submitted to and approved by VTA. Crimp tools shall be of the ratchet-type that do not release unless the wire terminal has been compressed to the proper thickness. Crimp tool shall be re-calibrated at regular, specified intervals using gauges provided by the crimp tool manufacturer.

6. Compression-type insulated terminal connections to terminal blocks shall use a single washer on top of the terminal. Wire eyes require two washers for one eye, three washers for two eyes. Connections shall be completed with double nuts torqued to the rated value of the nut.

7. There shall be no more than two wires on one AAR terminal binding post.

8. All wires and cables shall be identified during the termination process.

E. Signal Room, House, Case, and Junction Box Wiring

1. All external wires and cables shall be terminated at two multiple unit terminal blocks in accordance with AREMA 2011 Communications and Signals Manual Part 14.1.6, Recommended Design Criteria for Multiple Unit Binding Post Type Terminal Block, with wire terminals on one block and bus connector type per AREMA 2011 Communications and Signals Manual Part 14.1.15-1, Recommended Design Criteria for Terminal Connectors, Detail to complete the circuit.

2. All inter-rack vital and non-vital wiring shall terminate on AAR terminal blocks, in accordance with the applicable requirements of AREMA 2011 Communication and Signals Manual Part 14.1.6, Recommended Design Criteria for Multiple Unit Binding Post Type Terminal Block, with the single exception of microprocessor wiring. Edge connector cables from microprocessor printed circuit boards may be terminated on Wago-type spring compression terminals located at

the top of the microprocessor rack. Inter-rack wiring to/from the microprocessor, may terminate on these same Wago terminals.

3. If energy is distributed to various points in a signal equipment room and/or signal house, case, or junction box by wire loops, the details of the loops and its various connections shall be illustrated on the circuit plans. Such loops shall have both ends connected to the bus.

4. Both ends of all wires and terminal boards shall be tagged with nomenclature which is shown on the circuit plans. Tags shall be permanent, non-conductive, and attached to the wire and terminal board so as not be readily removed.

F. Identifying

1. All single and multiple-conductor wires and cables shall be identified whenever they enter or leave a junction box, manhole, housing, or enclosure and at all terminals.

2. Permanent non-conducting marking tags fastened securely to the wires and cables shall be used for identification.

3. Wire designations shall consistently conform to an overall scheme approved by VTA to indicate location, circuit, device, wire number, terminal branch, position, etc., in accordance with AAR symbols, and nomenclature. Letters and numbers shall be used to identify signal equipment room and signal house, case and junction box wires. They shall be identified with tags which show:

   a) The wire's origin.

   b) Circuit nomenclature (wire name).

   c) The wire's destination.

END OF SECTION 34 42 22

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SECTION 34 42 24

RAIL BONDING

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes the requirements for furnishing, installing, and testing rail bonding connections.

1.02 REFERENCED STANDARDS

A. American Railway Engineering and Maintenance of Way Association (AREMA):

1. Part 8 — Track Circuits.
2. Part 8.1.31 — Recommended Design Criteria For Copper Based Welded-Type Propulsion Rail-Head Bonds.
3. Part 8.1.32 — Recommended Design Criteria For Copper Based Exothermically Welded-Type Non-Propulsion Rail-Web Bonds And Track Circuit Connections.
4. Part 8.1.33 — Recommended Design Criteria For Copper Based Exothermically Welded-Type Propulsion Rail-Web Bonds And Track Circuit Connections.
5. Part 10.3.19 — Recommended Design Criteria For Ethelyne-Propylene Rubber Insulation for Wire and Cable.
6. Part 10.3.20 — Recommended Design Criteria For Neoprene, Chlorinated Polyethylene and Chlorosulfonated Polyethylene Jacketing for Wire and Cable.

B. California Public Utilities Commission (Cal. PUC):

1. G. O. No. 143-B — Safety Rules and Regulations Governing Light-Rail Transit.

C. Federal Railroad Administration (FRA), Code of Federal Regulations:

1. Part 236 — Rules, Standards, and Instruction Governing the Installation, Inspection, Maintenance, and Repair of Signal and Train Control Systems, Devices, and Applications.

1.03 QUALITY ASSURANCE

A. Rail bonding shall be installed in accordance with AREMA and FRA practices. Where a conflict exists between practices, the more stringent practices shall govern.

1.04 SUBMITTALS

A. Rail Head Bond Product Data: Submit product data for exothermic rail head bonds, including part numbers and specifications.

B. Rail Web Connection (Track Circuit) Product Data: Submit product data for exothermic rail web connections, including part numbers and specifications.

C. Rail Web Connection (Propulsion) Product Data: Submit product data for exothermic rail web connections, including part numbers and specifications.

D. Impedance Bond Center Tap Product Data: Submit product data for impedance bond center tap lug and related hardware, including part numbers and specifications.

E. 500 MCM Cable Data: Submit product data for the 500 MCM cable, including insulation and jacketing materials.

1.05 MEASUREMENT AND PAYMENT

A. Measurement: Rail Bonding shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Rail Bonding shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in this Section, complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 RAIL HEAD BONDS

A. General: Rail head bonds shall be Cadweld, manufactured by Erico, or owner approved equal.

1. Rail head bonds shall conform to AREMA recommended practice 8.1.31.
2. Rail head bonds shall be 250 MCM size.
3. Bonds shall be exothermically welded to head of rail.

2.02 RAIL WEB CONNECTIONS (TRACK CIRCUIT)

A. General: Rail web connections shall be Cadweld model SBTBBU4A, manufactured by Erico, or owner approved equal.

1. Rail web connections shall conform to AREMA recommended practice 8.1.32.
2. Connection shall be 3/16 inch pigtail type with compression sleeve connection end.
3. Connections shall be exothermically welded to web of rail.

2.03 RAIL WEB CONNECTIONS (PROPULSION)

A. General: Rail web connections shall be Cadweld, manufactured by Erico, or owner approved equal.

1. Rail head bonds shall conform to AREMA recommended practice 8.1.33.
2. Connection shall be 500 MCM cable size.

3. Connections shall be exothermically welded to web of rail.

2.04 IMPEDANCE BOND CENTER TAP CONNECTION

A. General: Impedance bond center tap connection lug shall be manufactured by Erico, or owner approved equal.

1. Connection lug shall be capable of connecting (4) 500 MCM cables.

2. Cables shall be connected to lug by means of exothermic welds.

2.05 500 MCM CABLE

A. General: 500 MCM cable shall be manufactured by an experienced cable manufacturer, as required in Section 34 42 20, Signal External Wire and Cable.

1. Wire shall be stranded untinned copper with minimum 61 strands

2. Insulation shall be rated for 1000 volt minimum, 90 degrees C, and in accordance with AREMA 10.3.19.

3. Jacket shall be chlorinated polyethelyne in accordance with AREMA 10.3.19.

PART 3 – EXECUTION

3.01 BONDING

A. Rail Head Bonds:

1. Provide rail head bonds around rail joints and retired insulated rail joints.

2. Each rail joint shall be bonded with (2) rail head bonds.

B. Rail Web Connections (Track Circuit):

1. Provide rail web connections for all new track circuit rail connections.

2. Bondstrand track lead shall be crimped to welded pigtail connection.

C. Rail Web Connections (Propulsion):

1. Provide rail web connections for all new propulsion rail connections.

2. Propulsion rail connections may be made by welded pigtail that is exothermically welded to propulsion cable, or by direct welding of propulsion cable to rail.

3.02 TESTING

A. All welded track connections shall be visually inspected for any defects.

B. At the request of the Resident Engineer, rail connection shall be tested by means of a “strike test” with a 5 lb hammer.

3.03 FIELD QUALITY CONTROL

A. Quality: The quality of the wayside signal system installation shall be ensured through the performance of tests and inspections made during the progress of this Contract and after completing the installation of equipment. Perform field installation inspections to ensure that all equipment furnished under this Contract is installed in compliance with the technical specifications.

END OF SECTION 34 42 24

SECTION 34 42 25

POWER SWITCH MACHINES AND LAYOUTS

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for furnishing, installing, and testing power switch machines and layouts. All new machines shall be dual control switch-and-lock movements.

1.02 REFERENCED STANDARDS

A. American Railway Engineering and Maintenance of Way Association (AREMA):

1. Part 12 — Switches.
2. Part 12.2.1 — Recommended Design Criteria and Functional Guidelines for Lockable Electric Motor Switch Operating Mechanism

B. California Public Utilities Commission (Cal. PUC):

1. G.O. No. 26-D — Regulations Governing Clearances on Railroads and Street Railroads with Reference to Side and Overhead Structures, Parallel Tracks, Crossings of Public Roads, Highways and Streets
2. G.O. No. 143-B — Safety Rules and Regulations Governing Light-Rail Transit

C. Federal Railroad Administration (FRA), Code of Federal Regulations:

1. 49 CFR Part 236 — Rules, Standards, and Instruction Governing the Installation, Inspection, Maintenance, and Repair of Signal and Train Control Systems, Devices, and Applications

1.03 SUBMITTALS

A. Power Switch Machine Identification Product Data: Submit material data and drawings for switch machine identification numbers, closed point letters and power switch "Danger" sign. Include material data, and drawings indicating proposed sign sizes, lettering sizes, and styles.

B. Power Switch and Lock Machine: Submit product information and drawings for lockable power switch machine. Include materials, parts lists, circuit diagrams, dimensions, and operation description.

C. Switch Rod Product Data: Submit product information for lockable power switch machine rods and related hardware.

D. Junction Box Data: Submit product information for lockable power switch machine junction box. Include materials, parts lists, and dimensions.

E. Switch Installation Drawings: Submit detailed installation drawings for each type of switch machine.

F. Test Reports: Submit test reports verifying compliance with testing requirements, per the requirements of Section 34 42 95, Signal System Testing.

1.04 QUALITY ASSURANCE

A. Cal. PUC: Installation shall conform to regulations established in the Cal. PUC G.O. No. 143-B.

B. AREMA: Installation shall conform to the recommendations of AREMA, Part 12, unless specified otherwise. Where the requirements of AREMA, or these technical specifications, conflict with requirements of Cal. PUC G.O. No. 143-B, the Cal. PUC shall govern.

C. FRA: Installation of switch machines shall conform to the requirements of FRA Part 236. Where the requirements of the FRA or these technical specifications conflict, the most stringent shall govern.

1.05 MEASUREMENT AND PAYMENT

A. Measurement: Power Switch Machines and Layouts shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Power Switch Machines and Layouts shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in this Section, complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 GENERAL

A. Provide new switch-and-lock (“lockable”) power switch machines for the new switches at Eastridge Interlocking.

B. For each standard lockable power switch machine, provide a number to identify the switch machine number. The number shall be white, 3-inch minimum, malleable metal numbers attached to the top of the switch machine housing, to indicate the number of the switch machine.

C. For each lockable power switch machine, provide a letter to identify the normal position of the switch. The letter shall be a black, 6-inch malleable metal letter "N" for attachment to the top of tie on the gauge side of the normally closed point.

D. For each lockable power switch, provide a metal sign which reads "Danger - Switch May Move at Any Time." Coordinate size, lettering, and sign placement with the Resident Engineer.

E. Switch Point Indicators are not required for these switches.

2.02 LOCKABLE SWITCH MACHINE LAYOUTS

A. General: Provide lockable power switch machine layout complete with switch rods, junction box, flex conduit, and all related hardware. Provide switch machines as manufactured by Alstom, Model 5F, or owner approved equal.

B. Construction: Construct the switch machine housing and cover of steel or cast aluminum, weatherproof, and size to adequately house the apparatus and wiring contained within.

C Point Locking: Provide lock bar and rod to lock switch point in position. Switch must be locked in order to provide a switch position indication.

D. Contacts: Provide contacts for normal and reverse switch position indication, selector lever position, and switch crank motor cutout. Shunt straps across switch position contacts shall shunt indication circuits when switch is in mid-throw.

E. Voltage: Switch machine shall operate at a nominal voltage of 110 Vdc.

F. Operation: Provide dual switch throw operation. A selector lever shall change operation from power to manual.

G. Clutch: Provide a clutch on the switch motor to slip in the event of an obstruction in the points.

H. Heater: Provide switch machine heater(s). Heaters shall operate at 110 Vac.

2.03 LOCKABLE SWITCH MACHINE CONTROLLER

A. General: Provide solid state power switch machine controller and all related hardware. Provide controller as manufactured by Alstom Signaling, HSC Model 300601-132X, or owner approved equal.

B. Construction: Controller shall be capable of being mounted in the space of a standard B2 relay plugboard.

C. Operation: Controller shall be capable of switching 110 Vdc to throw switch machine. Controller shall accept a biased 12 Vdc input to command the switch to throw normal or reverse.

D. Overload Protection: Controller shall provide overload protection. Overload current rating and time delay shall be user programmable.

PART 3 – EXECUTION

3.01 SWITCH MACHINE INSTALLATION

A. Locations: Install switch machine layouts as indicated on the Contract Drawings.

B. General:

1. Install switch machine layouts in accordance with CPUC GO 26-D and GO 143-B, and the approved Contractor-furnished installation drawings.

2. Install equipment in accordance with the manufacturer’s recommended procedures.

3. Provide all necessary hardware to provide a complete installation.

4. Install machine horizontally plumb.

5. Verify tightness of all bolts and installation of cotter pins.

6. Lubricate switch layout, including switch-and-lock mechanism, switch rods and connections, and switch points per manufacturer’s instructions.

7. Install VTA-provided locks to secure the switch machine housing immediately after installation.

3.02 SWITCH MACHINE OPERATION

A. General:

1. Switches shall be capable of being lined by TWC request, local control, or central control.

2. Switch position shall not indicate with a point obstruction of 1/4 inch or more. Switch position shall indicate with a point obstruction of 1/8 inch or less.

3.03 TESTING REQUIREMENTS

A. General: Perform a visual inspection to verify that all equipment has been installed and is ready for test. Utilizing the arrangement drawings, verify that all wiring is in place and equipment tags are correct, and indicate as such with a green pencil on the approved Location Plans.

B. Static Testing: Verify that:

1. The switch machine layout has been placed, installed and lubricated according to the approved installation drawing.

2. The switch machine is wired according to the up-to-date approved Location Plans. Correct wiring shall be indicated as such by marking with a green pencil.

3. The switch machine layout and wiring identification tags and markers are in place.

4. The switch machine is energized with the proper voltage and that the voltage remains within tolerance during operation. Record the voltage.

5. Switch point pressure against stock rail is correct.

6. All switch machine point detection contacts or proximity detectors are adjusted to provide no indication with a point obstruction of 1/4 inch or more, and to provide indication with a point obstruction of 1/8 inch or less.

7. Switch correctly indicates correspondence.

8. Switch point indicators display correct aspects.

C. Operational Testing: Refer to Section 34 42 95, Signal System Testing for requirements.

D. Dynamic Testing: Refer to Section 34 42 95, Signal System Testing for requirements.

E. Integration Testing: Refer to Section 34 42 95, Signal System Testing for requirements.

3.04 FIELD QUALITY CONTROL

A. Quality: The quality of the wayside signal system installation shall be ensured through the performance of tests and inspections made during the progress of this Contract and after completing the installation of equipment. Perform field installation inspections to ensure that all equipment furnished under this Contract is installed in compliance with the technical specifications.

END OF SECTION 34 42 25

SECTION 34 42 26

WAYSIDE SIGNALS

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes the requirements for furnishing and installation of wayside signals.

1.02 REFERENCED STANDARDS

A. American Railway Engineering and Maintenance of Way Association (AREMA):

1. Part 7 Signals.
2. Part 7.1.1 Recommended Design Criteria and Functional/Operating Guidelines for a Color-Light Signal, Doublet-Lens Type
3. Part 7.1.5 Recommended Design Criteria and Functional/Operating Guidelines for an LED Light Unit Used in Wayside Signal Applications

B. California Public Utilities Commission (Cal. PUC):

1. G.O. No. 26-D Regulations Governing Clearances on Railroads and Street Railroads with Reference to Side and Overhead Structures, Parallel Tracks, Crossings of Public Roads, Highways and Streets
2. G. O. No. 143-B Safety Rules and Regulations Governing Light-Rail Transit.

C. Federal Railroad Administration (FRA), Code of Federal Regulations:

1. Part 236 Rules, Standards, and Instruction Governing the Installation, Inspection, Maintenance, and Repair of Signal and Train Control Systems, Devices, and Applications

1.03 QUALITY ASSURANCE

A. AREMA: Wayside signals and LED light units shall conform to the recommendations of AREMA, Part 7, unless specified otherwise.

B. FRA: Installation of wayside signals shall conform to the requirements of FRA Part 236 and CPUC GO 26-D and 143-B. Where the requirements of the FRA, CPUC or these technical specifications conflict, the most stringent shall govern.

1.04 SUBMITTALS

A. Wayside Signal Head Product Data: Submit manufacturer data for each type of signal head, showing part numbers, dimensions, and specifications.

B. Wayside Signal Support Product Data: Submit manufacturer data for each type of mast and junction box base, showing part numbers, dimensions, and specifications.

C. LED Light Unit Product Data: Submit manufacturer data for each type of LED light unit, showing part numbers, dimensions, and specifications. Include documentation supporting the use of LED units in conjunction with the microprocessor lamp drivers.

1.05 MEASUREMENT AND PAYMENT

A. Measurement: Wayside Signals shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Wayside Signals shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in this Section, complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 WAYSIDE SIGNAL HEADS

A. Wayside signal head shall be model CLS-20R, manufactured by Siemens (formerly Safetran), or owner approved equal and meet the requirements of the VTA Standard Detail. Signal head shall meet the following minimum requirements:

1. Signal head shall be a 3- or 4-aspect head. Aspects shall be red, yellow, green and lunar white in a vertical alignment, with red at the top. Where the green is not required, the aspects shall be red, yellow and lunar white.

2. Signal hood and background shall be painted flat black. Rear of signal head and background shall be painted aluminum color. Backgrounds shall be 24 inch wide.

3. Signal head shall be mounted on top of a 5-inch nominal pipe size diameter mast.

4. Each compartment of signal head shall be capable of being individually locked.

2.02 WAYSIDE SIGNAL MAST AND BASE

A. The wayside signal mast and base shall be as shown on the VTA Standard Detail.

B. The wayside signal mast shall be industry standard 5-inch nominal pipe size diameter mast. The signal head shall be seven feet, eleven inches above top of rail to the center of the bottom aspect.

C. The base shall be the split type with junction box incorporated. The junction box shall be equipped with minimum of six duplex (double) AREMA terminals.

D. A signal number plate shall be installed. Lettering shall be 3inches high, white on a non-reflective black background.

2.03 LED LIGHT UNITS

A. LED light units shall be manufactured by General Electric Global Signaling/Gelcore, or owner approved equal. LED light units shall meet the following minimum requirements:

1. LED light units shall be 8 3/8 inches in diameter.

2. LED light units shall operate at a nominal voltage of 10 Vdc.

3. LED light units shall be compatible with interlocking microprocessor’s cold filament and hot filament light out detection circuitry.

PART 3 – EXECUTION

3.01 GENERAL

A. General: Install the new wayside signals, complete with LED light units, per the Contract Drawings.

3.02 SIGNAL SYSTEM INSTALLATION

A. Wayside Signals: Install signal assemblies as shown on the contract drawings. Minimum clearance to the edge of the background shall be 66 inches from centerline of tangent track. Increase clearance on curves and super elevated track. Mast shall be plumb. Aim the signal head to provide best visibility.

B. Wiring: Install wiring and tagging per the requirements of Section 34 42 22, Signal Internal Wiring.

3.03 SIGNAL SYSTEM TESTING

A. Wayside Signal Head: This test shall verify the operation of the wayside signal head. Testing shall verify that:

1. All wiring has been correctly installed. Correct wiring shall be indicated on the approved Location Plans by marking with a green pencil.

2. Voltage to each signal head aspect is within specifications.

3. Corresponding aspect(s) is displayed for lined route.

4. Signal wire tags are in place and have been verified.

3.04 FIELD QUALITY CONTROL

A. Quality: The quality of the wayside signal system installation shall be ensured through the performance of tests and inspections made during the progress of this Contract and after completing the installation of equipment. Perform field installation inspections to ensure that all equipment furnished under this Contract is installed in compliance with the technical specifications.

END OF SECTION 34 42 26

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SECTION 34 42 27

RELAYS

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes the requirements for furnishing, installing, and testing relays.

1.02 REFERENCED STANDARDS

A. American Railway Engineering and Maintenance of Way Association (AREMA):

1. Part 6 — Relays
2. Part 6.1.35 — Recommended Design Criteria for Alternating-Current Induction-Type Relay
3. Part 6.2.1 — Recommended Design Criteria for Tractive-Armature Direct-Current Neutral Relay (Plug-In Type)
4. Part 6.2.2 — Recommended Design Criteria for Vital Plug-In Relay Plugboards

B. California Public Utilities Commission (Cal. PUC):

1. G. O. No. 75-D — Regulations Governing the Protection of Crossings at Grade of Roads, Highways and Streets with Railroads in the State of California Safety Rules and Regulations Governing Light-Rail Transit
2. G. O. No. 143-B — Safety Rules and Regulations Governing Light-Rail Transit.

C. Federal Railroad Administration (FRA), Code of Federal Regulations:

1. Part 234 — Grade Crossing Signal System Safety
2. Part 236 — Rules, Standards, and Instruction Governing the Installation, Inspection, Maintenance, and Repair of Signal and Train Control Systems, Devices, and Applications

1.03 SUBMITTALS

A. Relay Product Data: Submit product information for each relay type used on the project. Include all product data and parts lists.

B. Relay Plugboard Product Data: Submit product information for each relay plugboard type used on the project. Include all product data and parts lists.

C. Relay Terminals: Submit product information for each relay terminal type used on the project. Include all product data.

D. Test Reports: Submit test reports verifying compliance with testing requirements, per the requirements of Section 34 42 95, Signal System Testing.

1.04 MEASUREMENT AND PAYMENT

A. Measurement: Relays shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Relays shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in this Section, complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 GENERAL REQUIREMENTS

A. General: Relays shall operate:

1. In temperatures of -40 degrees C (-40 degrees F) to +70 degrees C (158 degrees F).

2. Over a range of relative humidity from 0 to 95 percent non-condensing.

B. Ac vane vital track relays: Relays shall conform to AREMA part 6.1.35.

C. Dc vital relays: Relays shall conform to AREMA part 6.2.1.

2.02 VITAL RELAYS

A. DC neutral relays shall be 500Ω, B1 style, plug-in type, with a 6 front-back configuration. Relay shall be model A62-262, manufactured by Alstom, or owner approved equal.

B. DC neutral relays shall be 500Ω, B2 style, plug-in type, with a 12 front-back configuration. Relay shall be model A62-330, manufactured by Alstom, or owner approved equal.

C. DC biased relays shall be 500Ω, B1 style, plug-in type, with a 6 front-back configuration. Relay shall be model A62-125, manufactured by Alstom, or owner approved equal.

D. Other types of relays shall be B1 style, plug-in type, manufactured by Alstom, or owner approved equal. Coil resistance, contact arrangement, type of relay, proposed use, and model shall be submitted to VTA for approval before that type of relay may be used.

2.03 NON-VITAL RELAYS

A. 12VDC non-vital relays shall be 8-pin plug-in type, with a 2 front-back configuration. Relay shall be part KRPA-11DY-12, manufactured by Tyco Electronics, or owner approved equal.

B. 110VDC non-vital relays shall be 8-pin plug-in type, with a 2 front-back configuration. Relay shall be part KRPA-11DG-110, manufactured by Tyco Electronics, or owner approved equal.

C. 120Vac non-vital relays shall be 8-pin plug-in type, with a 2 front-back configuration. Relay shall be part KRPA-11AY-120, manufactured by Tyco Electronics, or owner approved equal.

2.04 VITAL RELAY PLUGBOARDS

A. Ac vane track relay plugboards shall be model N438689003, manufactured by Ansaldo (Hitachi), or owner approved equal.

B. B1 type relay plugboards shall be model 59686-005-01, manufactured by Alstom, or owner approved equal. B1 relay plugboards shall be equipped with a voltage test terminal except if two current test terminals are required when separate circuits feed two separate coils.

C. B2 type relay plugboards shall be model 59686-007-01, manufactured by Alstom, or owner approved equal. B2 relay plugboards shall be equipped with a voltage test terminal except if two current test terminals are required when separate circuits feed two separate coils.

2.05 NON-VITAL RELAY SOCKETS

A. Non-vital relay sockets shall be 8-pin type. Socket shall be part 27E122, manufactured by Tyco Electronics, or owner approved equal.

PART 3 – EXECUTION

3.01 INSTALLATION

A. General:

1. Provide and install complete relays, plugboards, terminals, and all related hardware.

3.02 TESTING REQUIREMENTS

A. General: Conduct a visual inspection to verify that all equipment has been installed and is ready for test. Utilizing the arrangement drawings, verify that all wiring is in place and equipment tags are correct, and indicate as such with a green pencil on the approved Location Plans.

B. Factory Testing: All vital relays shall be tested at the manufacturer’s facility prior to shipment to the contractor.

C. Field Testing: All vital relays shall be tested in their field locations prior to cutover testing.

3.03 FIELD QUALITY CONTROL

A. Quality: The quality of the wayside signal system installation shall be ensured through the performance of tests and inspections made during the progress of this Contract and after completing the installation of equipment. Perform field installation inspections to ensure that all equipment furnished under this Contract is installed in compliance with the technical specifications.

END OF SECTION 34 42 27

SECTION 34 42 29

MISCELLANEOUS SIGNAL PRODUCTS

PART 1 – GENERAL

1.01 SUMMARY

A. This Section describes includes the requirements for miscellaneous signal products provided in this Contract.

1.02 REFERENCED STANDARDS

A. American Railway Engineering and Maintenance of Way Association (AREMA):

1. Part 11.3.1 Recommended Design Criteria and Functional/Operating Guidelines For Primary Surge Protectors for Electrical Surge Protection of Signal Systems

2. Part 14.1.1 Recommended Design Criteria and Functional/Operating Guidelines For Solderless Crimp-Type Wire Terminals for Use in Wiring Signal Apparatus

3. Part 14.1.2 Recommended Design Criteria and Functional/Operating Guidelines For Solderless Screw-Clamp or Screwless Cage-Clamp Terminal Blocks Used In Wiring Signal Apparatus with Copper Wire Only

4. Part 14.1.5 Recommended Design Criteria for Molded Terminal Blocks

5. Part 14.1.11 Recommended Design Criteria for Binding Posts, Nuts and Washers, Details and Assemblies

1.03 SUBMITTALS

A. Surge Protection Product Data: Submit material data for lightning arrestors and equalizers. Include drawings, part numbers and specifications.

B. Wire Terminal Product Data: Submit material data for all sizes of ring terminals and fork terminals used on project. Include drawings, part numbers, and dimensions.

C. Cage-Clamp Terminal Block Product Data: Submit material data for all sizes of cage-clamp type terminal blocks. Include drawings, part numbers, dimensions, and specifications.

D. Molded Terminal Block Product Data: Submit material data for all terminal blocks, including lightning arrestor blocks and fuse blocks. Include drawings, part numbers, and dimensions.

E. Terminal Hardware Product Data: Submit material data for all terminal binding nuts, clamp nuts, washers, links, and test links. Include drawings, part numbers, and dimensions.

1.04 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 – PRODUCTS

2.01 SURGE PROTECTION

A. Lightning arrestors shall be heavy duty type, part number 022615-1X, manufactured by Siemens Rail Automation (formerly Invensys Rail), or owner approved equal:

1. Lightning arrestor shall meet guidelines of AREMA Part 11.3.1.
2. Lightning arrestor shall be air gap type.
3. Lightning arrestor shall be designed for circuit voltages of 0 – 50 Vdc and 0 – 175 Vac.

B. Equalizers shall be heavy duty type, part number 022700-1X, manufactured by Siemens Rail Automation (formerly Invensys Rail), or owner approved equal:

1. Equalizer shall meet guidelines of AREMA Part 11.3.1.
2. Equalizer shall be designed for circuit voltages up to 24 Vdc.

2.02 WIRE TERMINALS

A. Ring type wire terminals shall be manufactured by AMP/Tyco Electronics, or owner approved equal:

1. Ring terminals shall meet guidelines of AREMA Part 14.1.1.
2. Ring terminals shall be insulated.
3. Ring terminal shall be properly sized for wire gauge and terminal diameter.

B. Fork type wire terminals shall be manufactured by AMP/Tyco Electronics, or owner approved equal:

1. Fork terminals shall meet guidelines of AREMA Part 14.1.1.
2. Fork terminals shall be insulated.
3. Fork terminal shall be properly sized for wire gauge and terminal diameter.

2.03 CAGE-CLAMP TERMINAL BLOCKS

A. Cage-clamp type terminal blocks shall be manufactured by Wago, or owner approved equal:

1. Terminal blocks shall meet guidelines of AREMA Part 14.1.2.
2. Terminal blocks shall be capable of being jumpered together by means of a jumper pin/connector.
3. Terminal block configuration and size shall conform to the contract drawings.

2.04 MOLDED TERMINAL BLOCKS

A. Molded terminal blocks shall be part number 023390-11X, manufactured by Siemens Rail Automation (formerly Invensys Rail), or owner approved equal:

1. Terminal blocks shall meet guidelines of AREMA Part 14.1.5.

B. 3-post lightning arrestor terminal blocks shall be manufactured by Siemens Rail Automation (formerly Invensys Rail), or owner approved equal:

1. Lightning arrestor terminal blocks shall meet guidelines of AREMA Part 14.1.5.

C. Fuse blocks shall be part number 027614-1X, manufactured by Siemens Rail Automation (formerly Invensys Rail), or owner approved equal:

1. Fuse blocks shall be bakelite type.

2.05 TERMINAL HARDWARE

A. AREMA terminal binding (full) nuts shall be part number 023831, manufactured by Siemens Rail Automation (formerly Invensys Rail), or owner approved equal:

1. Binding nuts shall meet guidelines of AREMA Part 14.1.11.

B. AREMA terminal clamp (half) nuts shall be part number 023832, manufactured by Siemens Rail Automation (formerly Invensys Rail), or owner approved equal:

1. Clamp nuts shall meet guidelines of AREMA Part 14.1.11.

C. AREMA terminal washers shall be part number 023834, manufactured by Siemens Rail Automation (formerly Invensys Rail), or owner approved equal:

1. Washers shall meet guidelines of AREMA Part 14.1.11.

D. AREMA terminal insulated nuts shall be part number 023408-1X, manufactured by Siemens Rail Automation (formerly Invensys Rail), or owner approved equal:

1. Insulated nuts shall meet guidelines of AREMA Part 14.1.11.

2. Insulated nuts shall be bakelite type.

E. AREMA terminal test links shall be part number 024620-2X, manufactured by Siemens Rail Automation (formerly Invensys Rail), or owner approved equal:

1. Test links shall have 1 inch terminal spacing.

2. Test links shall be straight/flat type.

2.06 QUALITY ASSURANCE

A. General: During static or factory tests, verify that the signal hardware is installed correctly, and all terminals are tight.

PART 3 – EXECUTION

3.01 INSTALLATION

A. General:

1. Install signal hardware as shown on contract drawings, per manufacturer's instructions.

2. Verify proper crimping of all wire terminals.

3. Verify correct hardware buildup on all binding post terminals.

4. Verify tightness of all terminal binding posts and cage-clamps.

3.02 FIELD QUALITY CONTROL

A. Inspections: During routine field inspections and testing, verify that the field-installed hardware is correct and installed in an approved manner. Work shall not be considered complete until all hardware is correct and in place.

END OF SECTION 34 42 29

SECTION 34 42 30

WAYSIDE SIGNS

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes the requirements for wayside signs to be provided in this Contract.

1.02 REFERENCED STANDARDS

A. American Railway Engineering and Maintenance of Way Association (AREMA):

1. Part 14.6.1 Recommended Design Criteria for Signs Other Than for Railroad-Highway Grade Crossings.

1.03 SUBMITTALS

A. Wayside Sign Product Data: Submit the proposed wayside Beginning and End of Automatic Block, End of Line, speed limit, and red reflector disk and associated number signs. Include proposed mast, foundation, and hardware, where applicable. Include material data, parts lists, drawings indicating sign sizes, lettering sizes, and styles, and material and installation methods for installing signs on OCS poles, where applicable.

B. Sign Installation Drawings: Should an installation deviate from the LRT Standard Details, submit an installation layout. Submit individual installation drawings for unique installations. Refer to the Contract Drawings for such installation deviations. Where signs are installed on a wayside signal, indicate as such on the signal installation drawing.

1.04 MEASUREMENT AND PAYMENT

A. Measurement: Wayside Signs shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Wayside Signs shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in this Section, complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 EQUIPMENT

A. Beginning of Automatic Block Signs:

1. Provide metal signs for identification of Beginning of Automatic Block, as indicated on the Contract Drawings, per the requirements of the Contract Drawings.

2. Provide mast, foundation, and hardware for installation of each sign, unless specified or indicated otherwise.

B. End of Automatic Block Signs:

1. Provide metal signs for identification of End of Automatic Block, as indicated on the Contract Drawings, per the requirements of the Contract Drawings.

2. Provide mast, foundation, and hardware for installation of each sign, unless specified or indicated otherwise.

A. Red Reflector Disk Marker:

1. Provide a red reflector disk marker, as indicated on the Contract Drawings, per the requirements of the Contract Drawings. Provide a signal number, as indicated in the Contract Drawings, for each marker.

2. Provide mast, foundation, and hardware for installation of the sign, unless specified or indicated otherwise.

B. Speed Limit Signs:

1. Speed limit signs shall be installed as shown on the drawings JS101-JS103, Single Line Plan, of this Contract. The total quantity and number of each type of sign, however, may change and shall be verified with the Resident Engineer prior to construction.

2. Signs shall be 300 mm x 300 mm (12 in. x 12 in.) black letters on a yellow engineer grade reflective background, single-sided, 1.5 mm (0.06 in.) or greater aluminum, which comply with AREMA Signal Manual, Part 14.6.1, except as modified herein. The design of the number plate and size of the lettering shall be similar to that on the existing LRT System.

3. Where possible, install speed limit signs on wayside signals. Where two speeds are to be posted (such as at an interlocking switch), combine both speeds, and associated directional arrows on a 300 mm x 600 mm (12 in. x 24 in.) sign.

4. Coordinate location and placement of all speed limit signs with the Resident Engineer prior to installation.

C. Wayside Signal Signs: Provide a signal number plate for each signal assembly. Signal number plates shall comply with AREMA Signal Manual, Part 14.6.1, unless specified otherwise. Number plates shall be sheet steel or aluminum with white reflex reflecting lettering on a black synthetic enamel background. The design of the number plate and size of the lettering shall be similar to that on the existing VTA LRT System. Include number plates with the signal layouts, per the requirements of Section 34 42 26, Wayside Signals.

D. End of Line Signs:

1. Provide signs at Eastridge Station, as indicated on the Contract Drawings, utilizing 300 mm x 300 mm (12 in. x 12 in.) black letters on a yellow engineer grade reflective background, single-sided, 1.5 mm (0.06 in.) or greater aluminum, which comply with AREMA Signal Manual, Part 14.6.1, unless specified otherwise.

2. Provide mast, foundation, and hardware for installation of the signs.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Beginning of Automatic Block Signs: Install signs where indicated on the Contract Drawings. Coordinate final placement of each sign with the Resident Engineer prior to installation.

B. End of Automatic Block Signs: Install signs where indicated on the Contract Drawings. Coordinate final placement of each sign with the Resident Engineer prior to installation.

C. Red Reflector Disk: Install signs where indicated on the Contract Drawings. Coordinate final placement of each sign with the Resident Engineer prior to installation.

D. Speed Limit Signs: Based on the Contractor-provided block design, identify proposed locations of speed limit signs. Coordinate placement of all signs with the Resident Engineer prior to installation.

E. Wayside Signal Signs: Install the signal number plate for each signal assembly, and red disk marker, in accordance with the approved signal product data submittal. Ensure number plates are readable, under all conditions, at a distance of at least 15 m (50 ft.) when illuminated by the LRV headlights.

F. End of Line Signs: Install signs where indicated on the Contract Drawings. Coordinate final placement of each sign with the Resident Engineer prior to installation.

3.02 FIELD QUALITY CONTROL

A. Inspections: During routine field inspections and testing, verify that the field-installed tags and markings are correct and applied in an approved manner. Work shall not be considered complete until tags and markings are correct and in place.

END OF SECTION 34 42 30

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SECTION 34 42 35

TRAIN-TO-WAYSIDE COMMUNICATION

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes the requirements for furnishing and installation of Train-To-Wayside Communication (TWC) systems and loops.

1.02 REFERENCED STANDARDS

A. None

1.03 QUALITY ASSURANCE

A. Compatibility: TWC shall be compatible with existing VTA field and carborne TWC equipment.

1.04 SUBMITTALS

A. TWC Interrogator Data: Submit manufacturer data for each type of TWC interrogator, including all modules, power supplies, operating voltages, dimensions, etc.

B. TWC Loop Assembly – Submit shop drawing of TWC loop assembly, showing dimensions, materials, parts, etc.

C. Ballasted track TWC Loop – Submit shop drawing showing method of installing TWC loop assembly in ballasted trackwork. Drilling or otherwise modifying concrete ties will not be permitted.

D. Direct Fixation Track TWC Loop – Submit shop drawing of TWC loop installation on guard rail plinths in direct fixation track, showing all dimensions, parts, and method of installation.

E. Test Reports: Submit test reports verifying compliance with testing requirements, per the requirements of Section 34 42 95, Signal System Testing.

1.05 MEASUREMENT AND PAYMENT

A. Measurement: Train-To-Wayside Communication shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Train-To-Wayside Communication shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in this Section, complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 TWC INTERROGATORS

A. TWC interrogators shall be model HCS-V, manufactured by Hanning & Kahl, or owner approved equal. Interrogator shall meet the following minimum requirements:

1. Interrogators shall be compatible with existing VTA field and carborne TWC equipment.

2. Interrogators shall be capable of communicating with existing TWC loops (2 wire lead cable) and new bi-directional communication TWC loops (4 wire lead cable).

3. Interrogator shall operate at a nominal voltage of 24 Vdc from a 12Vdc to 24Vdc converter.

4. Interrogator shall provide normally open and normally closed relay output contacts, with a minimum of 8 relays per relay output card.

5. Interrogator shall be capable of bi-directional TWC communication for future use.

6. Interrogator shall be capable of Ethernet communication.

2.02 TWC LOOP ASSEMBLIES

A. All locations, except for the station platforms will require new TWC loop assemblies, as shown on the drawings. The loops shall meet the following minimum requirements:

1. Loops shall meet the interrogator manufacturer's minimum requirements.

2. Loop dimensions shall be in accordance with the Contract Drawings.

3. Loop shall be in a figure "8" configuration.

4. Loop wiring shall be in accordance with the Contract Drawings.

B. Ballasted track loops shall be fiberglass and wood panels as shown on the Contract Drawings.

PART 3 – EXECUTION

3.01 GENERAL

A. General: Install the TWC interrogator system, complete with loops and loop converter boxes, per the Contract Drawings and manufacturer recommendations.

3.02 SIGNAL SYSTEM INSTALLATION

A. Housings: Install TWC interrogators within the signal shelters, as shown on the Contract Drawings.

B. Trackway: Install TWC loop assemblies and loop converter boxes in the trackway, as shown on the contract drawings.

C. Wiring and Conduit: Install conduit and wiring per the requirements of Section 34 42 20, Signal External Wire and Cable.

D. Identification: Identify all TWC equipment and wiring per the requirements of Section 34 42 22, Signal Internal Wiring.

E. Programming: Program TWC relay outputs in accordance with the output tables on the Contract Drawings.

3.03 SIGNAL SYSTEM TESTING

A. TWC interrogator: This test shall verify the operation and programming of the TWC interrogator. Testing shall verify that:

1. All wiring has been correctly installed. Correct wiring shall be indicated on the approved Location Plans by marking with a green pencil.

2. Each TWC loop connected to interrogator is properly tuned/adjusted.

3. Test each loop with a test transponder to verify each programmed code activates its corresponding relay.

4. TWC equipment and wire tags are in place and have been verified.

3.04 FIELD QUALITY CONTROL

A. Quality: The quality of the wayside signal system installation shall be ensured through the performance of tests and inspections made during the progress of this Contract and after completing the installation of equipment. Perform field installation inspections to ensure that all equipment furnished under this Contract is installed in compliance with the technical specifications.

END OF SECTION 34 42 35

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SECTION 34 42 36

INDUCTIVE LOOPS

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes the requirements for furnishing and installation of LRV inductive loops for crossing activation.

1.02 REFERENCED STANDARDS

A. None

1.03 QUALITY ASSURANCE

A. Compatibility: LRV inductive loops shall be compatible with existing VTA field equipment.

1.04 SUBMITTALS

A. Inductive Loop Processor Data: Submit manufacturer data, including all modules, power supplies, operating voltages, dimensions, etc.

B. Inductive Loop Assembly – Submit shop drawing of inductive loop assembly, showing dimensions, materials, parts, etc.

C. Ballasted track Inductive Loop – Submit shop drawing showing method of installing inductive loop assembly in ballasted trackwork. Drilling or otherwise modifying concrete ties will not be permitted.

D. Direct Fixation Track Inductive Loop – Submit shop drawing of inductive loop installation on guard rail plinths in direct fixation track, showing all dimensions, parts, and method of installation.

E. Test Reports: Submit test reports verifying compliance with testing requirements, per the requirements of Section 34 42 95, Signal System Testing.

1.05 MEASUREMENT AND PAYMENT

A. Measurement: Inductive Loops shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Inductive Loops shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in this Section, complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 INDUCTIVE LOOP PROCESSORS

A. LRV Inductive Loop Processors shall be model U-1400, manufactured by Reno A&E, or owner approved equal. Loop processor shall meet the following minimum requirements:

1. Loop processors shall be compatible with existing VTA field equipment.

5. Loop processors shall provide operation for both directions (normal and reverse).

6. Loop processor shall be capable of Ethernet communication.

2.02 TWC LOOP ASSEMBLIES

A. The loops shall meet the following minimum requirements:

1. Loops shall meet the manufacturer's minimum requirements.

2. Loop dimensions shall be in accordance with the Contract Drawings.

3. Loop shall be in a figure "8" configuration.

4. Loop wiring shall be in accordance with the Contract Drawings.

B. Ballasted track loops shall be fiberglass and wood panels as shown on the Contract Drawings.

PART 3 – EXECUTION

3.01 GENERAL

A. General: Install the LRV inductive loops per the Contract Drawings and manufacturer recommendations.

3.02 SIGNAL SYSTEM INSTALLATION

A. Housings: Install LRV inductive loop processors within the signal cases, as shown on the Contract Drawings.

B. Trackway: Install LRV inductive loop assemblies in the trackway, as shown on the contract drawings.

C. Wiring and Conduit: Install conduit and wiring per the requirements of Section 34 42 20, Signal External Wire and Cable.

D. Identification: Identify all LRV inductive loop equipment and wiring per the requirements of Section 34 42 22, Signal Internal Wiring.

3.03 SIGNAL SYSTEM TESTING

A. Inductive Loop Processor: This test shall verify the operation and programming of the Inductive Loop Processor. Testing shall verify that:

1. All wiring has been correctly installed. Correct wiring shall be indicated on the approved Location Plans by marking with a green pencil.

2. Each inductive loop connected to loop processor is properly adjusted.

3. Test each loop to verify it activates its corresponding relay.

4. Inductive loop equipment and wire tags are in place and have been verified.

3.04 FIELD QUALITY CONTROL

A. Quality: The quality of the wayside signal system installation shall be ensured through the performance of tests and inspections made during the progress of this Contract and after completing the installation of equipment. Perform field installation inspections to ensure that all equipment furnished under this Contract is installed in compliance with the technical specifications.

END OF SECTION 34 42 36

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SECTION 34 42 40

SIGNAL EQUIPMENT HOUSINGS

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes the requirements for designing, furnishing, installing, and testing LRT signal houses and cases, signal racks, signal junction boxes, and associated hardware and accessories.

1.02 REFERENCED STANDARDS

A. American National Standards Institute (ANSI):

1. Z55.1 Gray Finishes for Industrial Apparatus and Equipment

B. American Railway Engineering and Maintenance of Way Association (AREMA):

1. Part 2.4.30 Recommended Instructions for Painting
2. Part 14.1.5 Recommended Design Criteria for Molded Terminal Blocks

C. American Society for Testing and Materials (ASTM):

1. A48 Standard Specification for Gray Iron Castings
2. A153/A153M Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

D. California Building Code (CBC):

1. Title 24 Division III, Earthquake Design

E. Electronic Industries Association (EIA):

1. 310-D Cabinets, Racks, Panels, and Associated Equipment

F. Federal Railroad Administration (FRA), Code of Federal Regulations

G. National Fire Protection Association (NFPA):

1. 70 National Electrical Code
2. 72 National Fire Alarm and Signaling Code

1.03 DELIVERY, STORAGE AND HANDLING

A. Delivery: Deliver material and components carefully to avoid breakage, denting and scoring finishes. Do not install damaged equipment.

B. Storage: Store materials in original containers and cartons and in clean dry space and protect from weather and construction traffic.

1.04 QUALITY ASSURANCE

A. Codes and Standards: Products shall be manufactured and used in accordance with the following requirements or standards: Federal Communications Commission (FCC), National Electrical Code (NFPA 70), Underwriters Laboratories (UL), Department of Labor - Occupational Safety and Health Administration (OSHA) and all applicable federal, state and local requirements.

B. Signal Equipment: Design and install signal related housings, cases, and other associated equipment in accordance with regulations established in the applicable portions of American Railway Engineering and Maintenance of Way Association (AREMA), and the Federal Railroad Administration (FRA), Code of Federal Regulations.

1.05 DEFINITIONS

A. Factory Acceptance Tests: Tests performed at the Contractor's facilities before shipment to verify compliance with the technical specifications and quality standards.

B. Field Acceptance Tests: On-site field tests which exercise each system function through its required operations, including the imposition of simulated conditions, to prove that the installation complies with specified requirements. Field acceptance testing is comprised of three basic types of tests; Static, Dynamic, and Operational.

C. Static Testing: On-site tests performed to verify proper operation of the individual components of the Signal System.

D. Dynamic Testing: On-site tests performed to verify proper operation of the Signal System in conjunction with operation of the VTA LRT vehicle.

E. Operational Testing: On-site tests performed to verify that the all components, equipment, subsystems, and interfaces to other systems, function safely and properly with each other.

1.06 SUBMITTALS

A. Housing Product Data: Submit housing product data, including mechanical drawings, structural drawings, ventilation, lighting, housing seismic springs, and all hardware required to complete the installation. Include parts lists. Include calculations and documentation that the housing seismic springs meets the requirements of CBC Title 24, Division III, for Seismic Hazard Zone 4. Include calculations and documentation that lighting and ventilation designs meet contract requirements. Submit cable tray product data.

B. Junction Box Product Data: Submit junction box product data, including mechanical drawings, terminal block layouts, mounting details, and all hardware required to complete the installation. Include parts lists.

C. Signal Rack Product Data: Submit rack and terminal board product data, including mechanical drawings, structural drawings, mounting details (including seismic support, where applicable), and all hardware required to complete the installation. Include parts lists.

D. House and Case Layouts: Submit layout plans for each housing, including cable tray layout, rack layout, battery chargers, battery layouts, wall-mounted equipment, ground plates, and all other equipment to be installed in the housing. Provide dimensions for all equipment, including dimensions between equipment, between equipment and housing walls, doors, etc. Include proposed locations for housing nameplates.

E. Case Installation Plans: Submit an installation plan for each location, including foundation design, formwork design and product information, housing seismic spring installation, local conduit installation and extensions, conduit interfaces to the CSD, conduit stubup entry details (through foundation into housing), grounding, clearance requirements, etc. Include parts lists where applicable.

F. Fire Alarm System: Submit interconnection drawing, catalog cuts, and operation manual for the fire alarm system.

G. Test Reports: Submit test reports verifying compliance with testing requirements, per the requirements of Section 34 42 95, Signal System Testing.

1.07 MEASUREMENT AND PAYMENT

A. Measurement: Signal Equipment Housings shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Signal Equipment Housings shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in this Section, complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 SIGNAL SHELTERS

A. A Signal Houses will be provided at Story Station and Eastridge Interlocking, as shown on the drawings. These will be the buildings with 8" CMU walls. Refer to Architectural and Mechanical drawings of this Contract for details. House shall accommodate all equipment required to operate the signal system. Maintain the space around the house for full opening of doors and ground rod installation as indicated.

B. Signal Cases shall be provided at the locations indicated on the Contract Drawings. Case sizes shown on the Contract Drawings are the minimum sizes to be provided. Provide pre-fabricated stainless steel cases, sized to accommodate all equipment required to operate the signal system.

C. General: Case or house shall not encroach on the LRT vehicle's dynamic envelope, or emergency walkways, and shall meet all other requirements specified herein. Case or house shall provide enough space to accommodate all required racks and equipment.

1. Pre-fabricate and pre-wire cases as one complete unit, transportable to the job site for installation.

2. Contractor must provide foundations, seismic springs, equipment racks, power supplies and battery chargers, batteries, grounding system, thermostatically controlled ventilation, temperature monitoring, cable trays, lighting, electrical outlets, conduit and concrete risers, etc., as specified and as required to provide a complete installation.

D. Material:

1. Construct cases of stainless steel. Coat the exterior of the housings with graffiti resistant coating, as approved by the Resident Engineer. Paint the interior white or gray.

2. Provide door openings for cases and houses as shown on the drawings. Provide a latch to hold all doors open in 90-degree and 180-degree positions. Also provide an adjustable chain which will allow the doors to be held open to a lesser amount. Door hinges shall be replaceable castings with bronze or stainless steel pins. Provide three-point latches to keep the door closed, equipped for VTA padlocks. Signal House doors shall be able to be opened from inside when the door is locked on the outside.

3. Provide a minimum of 2 lifting plates for installation and removal of the Case. Provide thickness and strength to accommodate final housing weight with all equipment installed.

4. Due to clearance constraints at the aerial structure back doors will not be provided for signal cases. External cables will be pulled from cable entrance at the back side of the case to the front side for termination. Therefore, minimum of 18" gap between signal case bottom and termination board must be provided.

5. Insulation shall be provided on the interior of the roof and external walls of houses and cases. Insulation shall meet local building code requirements for uninhabited electrical equipment spaces.

E. Accessories:

1. Equip for terminating signal cables, with all wiring accessible from the front.

2. Doors and other openings shall be gasketed to provide for a dustproof and weatherproof enclosure.

3. In the case, provide two 120 Vac, 60 W light receptacles with an insulated pull chain, one on each end in the front.

4. In the front of the case, provide two 120 Vac duplex convenience outlets with a ground fault interrupter, one on each end.

5. Equip the house with 120/240-volt load center, a minimum of six duplex outlets with ground fault interrupters, and a minimum of four, four-foot fluorescent light fixtures, each with two lamps. Lights and outlets shall be located so they are not blocked by equipment or racks. The lights shall be arranged to provide good lighting to the fronts of the racks.

6. Equip all housings with vent fans thermostatically controlled. The thermostat shall be adjustable from 30 degrees F to 104 degrees F.

   a. The vent fans shall be covered with fine mesh stainless steel, copper or brass screening. The exterior of the ventilated openings shall be hooded to minimize the entrance of precipitation.

   b. Provide replaceable air filters on all door louvers.

   c. Fan screens or filters shall be easily pulled out without having to remove screws, bolts, nuts, cover plates, or the fan itself.

7. Thermostatically controlled air conditioning shall be provided for all houses and cases that contain electronic equipment. The air conditioning shall be capable of maintaining the internal house temperature at 85 degrees F with an ambient external temperature of 110 degrees F. The air conditioning system and ventilation fan shall be interlocked so that both cannot be on at the same time.

8. Provide a fire alarm system in accordance with NFPA 72 in bungalows. The system shall incorporate smoke detectors using both ionization and photoelectric detection. The control panel shall operate from 120 V ac using a dedicated circuit from the breaker box. The panel shall include batteries to maintain operation for 24 hours in the event of ac power failure. Alarm contacts shall be included and shall be connected to the SCADA system to transmit the alarm. The fire alarm system shall be configured for a normally unoccupied space. An audible alarm shall be provided. Latching indications with manual reset shall be provided to display the location of tripped smoke detectors.

F. Terminal Boards: Fire retardant terminal boards shall be provided for mounting of terminal blocks and equipment. The board dimensions including thickness of the board shall be selected to meet the requirements of this Contract from the manufacturer's standards, subject to the approval of the Resident Engineer. The terminal board shall have 20 percent spare capacity. Paint white or neutral gray, using fire-retardant paint.

G. Signal Housing and Case Signs:

1. Provide nameplates for each new signal case and house which indicate the location and number designation of the housing (ex: Eastridge ER150), which conform to AREMA Signal Manual, Part 14.6.1, unless specified otherwise. The number associated with the housing or case, for clarification purposes, is based on milepost.

2. Provide LRT housing nameplates 5.25 in. x 22 in. x 0.125 in. thick, made of embossed sheet aluminum. Provide black lettering, Egyptian style lettering 2.25 in. x 1.5 in. centered in sign, on a white background. Provide two nameplates per housing, fastened by a strong durable, waterproof self adhesive, as recommended by the manufacturer. Locate the nameplates on the outside of housing where visible from the trackside. Coordinate sign placement with the Resident Engineer.

2.02 SIGNAL EQUIPMENT RACKS

A. General:

1. Provide equipment racks of open-frame weldments to mount standard 19 inch panels for standard LRT signal equipment. Construct the frame of minimum 14 gauge cold-rolled steel. Design the frame unit for installation on 24 inch centers maximum. Construct panel-mounting angles with standard hole spacing in accordance with EIA 310-D.

2. Anchor and secure racks to minimum 12 gauge thick cold-rolled steel bases, installed under the racks and welded or bolted to the housing floor, as approved.

    a. The rack base and anchoring method shall provide for a self-supporting equipment rack that can withstand overturning moments caused by cable-pulling or earthquake effects without auxiliary support or bracing from the ceiling or side walls. As a minimum, the floor anchoring shall withstand the overturning moment of a 445 N force applied at the top of the rack in a horizontal direction. Auxiliary support shall be permitted with prior Resident Engineer approval only.

    b. Maximum installed rack height shall be 2.3 meters (7.5 feet). Racks shall be of the same height.

3. Provide chassis supports or guides for auxiliary support of heavy equipment, such as power supply equipment, if not wall mounted. Make chassis supports of minimum 11 gauge thick cold-rolled steel capable of being mounted directly to panel-mounting angles and allowing side-to-side guide adjustment. Close with 16 gauge thick minimum cold-rolled steel sheet at ends of rack rows.

4. Furnish a bolted-type grounding post with each rack to permit removal of ground wire connection.

5. Paint racks gray, conforming to ANSI Z55.1, color No. 61.

6. Provide cable support bars and hardware to protect wiring and cabling from vibration, chafing, and rubbing, and to relieve stress. Construct edges to prevent damage to cabling or wiring. Provide grommets and padded edges whenever cable rounds a metal edge.

7. Provide cable ties to keep bundles of internal and external wiring separate. Implement wire harnessing to provide neat and orderly routing, with wires to each device exclusive and together.

8. Provide terminals meeting the requirements specified in Part 14.1.5 of the AREMA Signal Manual. Provide insulation caps for terminals with a nominal potential greater than 50 V.

9. Provide a minimum of 10 percent spare space on each rack.

B. Terminal Boards:

1. Equip the terminal boards with AREMA 3-post arrestor/terminal blocks for terminating signal cables, with all wiring accessible from the front.

2. Provide terminal blocks with AREMA insulated test links, with a "gold nut" type terminal, which permits the room wiring to be isolated from the field wiring on an individual basis without removing the wires from their terminals.

2.03 HOUSING FOUNDATIONS

A. General:

1. Take care and prevent damage to the existing and new Combined Systems Ductbank (CSD). Remove temporary manholes, pullboxes, or other forms of protection around the conduit at the case interface point, and extend the conduit to the Contractor-provided foundation. Coordinate installation of the conduit, as it transitions into the case and penetrates the foundation, to provide the most logical transition of cable from the CSD to the housing cable tray. Make all modifications necessary to existing conduit stub-ups, including extending or cutting if necessary, to complete the interface between the case and the CSD.

2. Provide concrete foundation pad and piers on which to set the signal cases in accordance with drawings of this Contract and VTA Standard Details. Size, in width, length, and depth, to accommodate the case and fit within the available space, and to support the loads imposed by the case and all equipment therein. Include all framing and reinforcement required to complete the installation.

3. Top of foundation slab surrounding the housing shall be level, and designed relative to the site-specific ballast elevations. Ballast elevation shall be 1 inch minimum lower than pad elevation all around.

PART 3 – EXECUTION

3.01 GENERAL REQUIREMENTS

A. Installation:

1. Develop installation procedures in accordance with the standards defined in these technical specifications.

2. Perform installations in accordance with the approved installation plans.

3. Prepare foundation bases by installing Seismic Zone 4-rated anchor bolts (where required) to a depth of at least 100 mm (4 inches).

3.02 SIGNAL HOUSING INSTALLATION

A. General:

1. Notify the Resident Engineer immediately and propose a workaround if the space provided for the signal housings is not adequate to accommodate all necessary equipment.

2. Install the wayside signal housings, and associated foundations, where indicated on the Contract Drawings, and as required to provide a complete installation. The housings shall be level and plumb and sized to consider equipment needs. Provide verification that the design does not encroach the vehicle’s worst cable dynamic envelope.

3. Coordinate the foundation and housing layout with the existing and new CSD conduit.

4. Lock each housing door after installation with temporary locks. Replace temporary locks with Contractor-provided VTA locks upon system acceptance.

5. Place and maintain an up-to-date copy of the Location Plan set in the housing.

6. Install housings on foundations using lifting plates. Utilize the appropriate equipment to lift the housing onto the foundation, taking care not to damage the foundation or conduit stub-ups.

7. Install the embossed metal nameplates on the outside of each housing which identifies the interlocking or control location designation number, per the requirements of 2.01 F.

3.03 SIGNAL CASE INSTALLATION

A. General:

1. Provide Signal Cases at the locations indicated on the Contract Drawings. Mount case on top of foundation piers.

2. Size to consider equipment needs, however, the case itself shall not encroach into emergency walkways or into the vehicle dynamic envelope. Provide verification that the installation meets clearance requirements.

3. Coordinate placement of the case and foundation with the existing CSD and emergency walkway.

4. Install grommets or use other methods to protect cables from abrasion. Where cables are routed vertically, provide proper support as necessary to relieve strain. In no case shall the weight of cables be allowed to pull against cable terminations.

5. To the extent possible, install equipment in the case in accordance with CBC, Title 24, Division III, for Seismic Hazard Zone 4.

6. Seal all wire and cable entrances with an approved resilient sealing compound made expressly for the purpose.

7. Install LRT signal nameplate and UPRR U.S. DOT/AREMA (formally AAR) inventory number signs, per the requirements of 2.01 F.

8 Lock each housing door immediately after installation with temporary locks. Replace temporary locks with Contractor-provided VTA locks upon system acceptance.

9. Place and maintain an up-to-date copy of the Location Plan set in the case.

B. Case Layout:

1. Coordinate case placement and layout with the CSD and other nearby equipment. Adjust as necessary, within the limitations of the facilities provided, to provide sufficient clearances. Adjust length if required to provide sufficient space for equipment, including batteries, with a sufficient quantity of terminals, and space to accommodate minimum bending radius of wires and cables.

2. Installation of the equipment shall meet or exceed, but not be limited to, the following guidelines and criteria:

   a. Orient logically from the maintenance and operational perspective. Test points shall be readily accessible.

   b. Provide adequate room for adjustments without interference from other equipment.

   c. Provide adequate room for unit replacement. Units must be capable of being replaced without removal of other equipment, moving wire harnesses, etc.

   d. Provide for specific electrical requirements, such as where short wire connections are required, grounding considerations, and electromagnetic isolation.

   e. Equipment in cases shall not be over-crowded or crammed. To the extent practical, layout shall provide for space for future additions or changes.

   f. Adequate provision for space and routing shall be made for the entrance and termination of cables, and for wiring harnesses.

3.04 SIGNAL EQUIPMENT RACK INSTALLATION

A. General:

1. Group types of equipment racks and equipment on the racks in a logical manner to make troubleshooting easy.

2. Arrange racks so that 3 feet minimum exists between rows of racks or between front/back of rack and housing walls, unless indicated or approved otherwise. Arrangement shall permit all corrective and preventative maintenance to be easily performed. Mount rack mounted equipment a minimum of 12 inches above the floor.

3. Provide individual mounting and support equipment, in accordance with CBC, Title 24, Division III, for Seismic Hazard Zone 4, for racks not installed in housings that have been seismically supported as a whole.

4. Place relays at the height that permits easy viewing of contacts, while not being obscured by other equipment wiring.

5. Assemble racks one to another to form a row. In housings, signal racks do not need to be electrically isolated, however, they shall be electrically isolated from all Communications racks.

6. Group equipment on racks so that similar types of equipment or functions of a similar nature are together.

7. Install the LCP at a height that permits eye level viewing for an average-height person. Coordinate with placement of the plan table, as specified and as indicated on the Contract Drawings.

8. Do not place equipment less than 12 in. or higher than 68 in. above the floor of the case or bungalow, unless otherwise approved.

3.05 CSD INTERFACE

A. General: Make all modifications necessary to existing conduit stub-ups, including extensions and relocations to complete the interface between the housings/cases and other signal equipment to the CSD.

3.06 HOUSING SITEWORK AND AESTHETICS

A. Final Grading: Perform final grading and cleanup of each housing site.

3.07 TESTING REQUIREMENTS

A. Testing shall be in accordance with Section 34 42 95, Signal System Testing.

3.08 FIELD QUALITY CONTROL

A. Quality: The quality of the Signal Systems installation shall be ensured through the performance of tests and inspections made during the progress of this Contract and after completing the installation of equipment. Perform field installation inspections to ensure that all equipment furnished under this Contract is installed in compliance with the technical specifications.

3.09 PROTECTION OF BALLAST

A. Contamination: Take all of the necessary precautionary measures to ensure that track ballast is not fouled (contaminated with dirt or sub-ballast) during the course of the Work. Minimize any disruption to the ballast after it has been dressed by the preceding facilities contract, and re-dress any ballast which has been disturbed.

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SECTION 34 42 41

POWER DISTRIBUTION, BATTERIES, AND CHARGERS

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes the requirements for furnishing and installation of batteries, battery chargers, power supplies, and distribution systems for signal system equipment at the various locations included in this Contract.

B. Signal System:

1. Dc Power Supply:

   a. 12 Vdc power supplies shall be furnished and installed to serve the operation of LRT Signal System logic.

   b. 110 Vdc power supplies shall be furnished and installed to serve all powered switch machines at the new crossover and pocket track switches.

2. Dc-dc Converter: Furnish and install 12Vdc to 24Vdc converters for power to TWC interrogators.

1.02 REFERENCED STANDARDS

A. American Railway Engineering and Maintenance of Way Association (AREMA):

1. Part 1.5.1 Recommended Instructions for the Installation and Maintenance of Solid State Equipment

2. Part 9.1.15 Recommended Design Criteria for Nickel Cadmium Pocket Plate or Fiber Plate Alkaline Storage Battery

3. Part 14.2.10 Recommended Design Criteria for Transformer, Dry Type, Self-Cooled

4. Part 14.2.15 Recommended Design Criteria for Resistors

B. National Electrical Manufacturers Association (NEMA):

1. ST 20 Dry-Type Transformers for General Applications

2. 250 Enclosure for Electrical Equipment (1000 volts maximum)

3. ICS 4 Industrial Control and Systems Terminal Blocks

4. WC5 Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy

C. Institute of Electrical and Electronic Engineers (IEEE):

1. STD 450 Procedure for Battery Capacity Tests

D. American National Standards Institute (ANSI):

1. Z55.1 Gray Finishes for Industrial Apparatus and Equipment

E. Underwriters Laboratories, Inc. (UL):

1. 67 Panelboards

2. 1059 Terminal Blocks

1.03 QUALITY ASSURANCE

A. Loads: All components furnished under this Section shall be rated for a minimum of 25 percent above the actual operating load.

B. UL Listing: All equipment furnished under this Section shall be UL listed, unless approved otherwise by the Resident Engineer.

C. Grounding: All grounding shall be in accordance with EIA, National Electric Code, local standards, and Section 34 42 42, Grounding, except as modified herein.

1.04 SUBMITTALS

A. Power Supply Product Data: Submit manufacturer data for the following equipment, including as a minimum, input and output voltage tolerances, physical dimensions, temperature ranges, monitoring and alarm features, and regulation without battery:

1. 12 Vdc battery chargers.

2. 110 Vdc battery chargers.

3. Dc to ac inverters.

4. Dc-dc Converters

5. Battery Product Data: including battery materials, ampere-hour and voltage characteristics, temperature characteristics, physical dimensions, and installation details.

B. Power Calculations: Submit calculations for each power supply location demonstrating the capability of the proposed equipment to adequately serve the load demands of the connected equipment. All worksheets shall be included with the submittal. Calculations shall show the following:

1. Peak demand of all connected equipment.

2. Amp hour capacity required for the stated time period and duty cycle.

3. Peak demand of all connected equipment and standby batteries recharging.

4. Recharge time of batteries with stated duty cycle of load.

C. Test Reports: Submit test reports verifying compliance with testing requirements, per the requirements of Section 34 42 95, Signal System Testing.

1.05 MEASUREMENT AND PAYMENT

A. Measurement: Power Distribution, Batteries, and Chargers shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Power Distribution, Batteries, and Chargers shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in this Section, complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 BREAKER PANELS

A. General:

1. Panelboards shall conform to UL 67.
2. Provide the panel in NEMA Type 1 enclosure meeting the requirements of NEMA 250, suitable for wall mounting. Provide hinged doors, equipped with locking cylinder housings.

2.02 SIGNAL SYSTEM POWER SUPPLIES

A. Design Requirements: Power supplies shall meet the following minimum requirements:

1. Supply shall be capable of operating the signal equipment for normal revenue service with the battery disconnected for servicing. Provide supply capable of operating with input voltage of either 120 Vac or 240 Vac, +10 percent to –15 percent at 60 Hz +/- 0.5 Hz.
2. Provide a supply capable of supplying 125 percent of the load necessary to maintain normal revenue service, while simultaneously recharging the associated batteries within 8 hours.
3. The power supply shall contain a voltage failure light, an output ammeter, and an output voltmeter.
4. Clearly and permanently label power supplies with the manufacturer's name, serial number, part or model number, and the input and output rating.
5. Provide a dry contact for power supply failure detection, which shall cause an indication to OCC.
6. Provide power supply capable of withstanding 600 V, 60 Hz applied for 1 minute between each input lead connected together and the housing/room/case, between both output leads connected together and the housing/room/case, and between input leads connected together and output leads connected together.

B. TWC: Provide a dc to dc converter to provide power to the TWC interrogators, complete with all cabling and hardware required to complete the installation.

2.03 SIGNAL SYSTEM DC POWER SUPPLIES

A. Logic:

1. Battery chargers shall be model ERBC-C, manufactured by National Railway Supply, or owner approved equal.

2. Provide 12 Vdc power systems for operation of the Stevens Creek bungalow and new signal cases, for signal system logic, and switch position indicators.

3. Provide backup power for signal logic and power switch machines, and all other equipment necessary to continue normal revenue operations for a period of 8 hours.

4. The batteries shall be appropriately rated, and float charged by a separate charger, unless approved otherwise. The ampere hour rating shall be based on the 8-hour discharge rate to 1.10 V per cell at a temperature of 25 degrees C (77 degrees F).

5. The charging unit's electrical characteristics shall match the battery type and configuration and be sufficiently regulated to ensure optimum battery life and performance. The design shall provide reliable operation, monitoring, test facilities, and low maintenance.

6. Provide dry contacts on each power supply for failure detection circuitry, which shall cause an indication to OCC in the event of a power supply failure.

7. The 12 V power supplies shall be derived from full wave rectifiers. Unit shall be equipped with dc voltmeter, and dc ammeter of 2 percent accuracy. Rectifying unit shall be silicon diodes designed for easy replacement. Dc voltage shall be maintained within 2 percent at any load from no load to full load with a 10 percent variation of ac input voltage. The rectifier shall be temperature compensated.

8. Provide chargers that deliver a stabilized output voltage, are temperature compensating, and output current limiting. Furnish chargers that automatically adjust their output current according to the load and the demand on the battery.

B. Switch Machines:

1. Provide 110 Vdc battery chargers and batteries to provide power for all switch machines.

2.04 SIGNAL SYSTEM BATTERIES

A. General:

1. Batteries shall be low maintenance, valve regulated, nickel cadmium, type Ultima SLM as manufactured by SAFT, or owner approved equal, meeting the recommendations of AREMA Signal Manual, Part 9.1.15.

2. Batteries shall utilize gas recombination technology. Gas recombination shall take place at a minimum 80 percent efficiency, measured under normal float conditions when the electrolyte level is at the maximum line.

3. Battery capacities shall be sized appropriately.

4. Nominal life of battery under normal float conditions shall be 20 years, but in no case less than 15 years.

5. Batteries shall be furnished fully charged and ready for service and shall include all material for installation and connection.

B. Battery Sizing: Provide a minimum capacity when 80 percent charged for minimum of service operation specified herein. Minimum voltage at the end of this cycle shall be 1.15 V per cell at 25 degrees C (77 degrees F). Cells shall have a specific gravity of 1.180 +/- 0.02 at 25 degrees C (77 degrees F), when fully charged. Determine the battery capacity in accordance with IEEE STD 450. Base calculations for battery sizing on the following criteria:

1. Headway of 3 minutes.

2. Voltage measured at locking switch machine terminals shall not fall below 100 V under overload conditions.

C. Accessories: Provide one of each of the following accessories for each battery location:

1. Cell lifting sling and spreader.

2. Quart of terminal grease.

D. Battery Racks:

1. Provide two-step battery racks for each battery location to minimize space requirements. Make racks of structural steel and provide with insulating plastic strips to cover all supports and restraining rails that contact the battery cells.

2. Paint racks with acid-resistant paint conforming to ANSI Z55.1, No. 61, black.

3. Battery racks shall be constructed and installed to prevent cell displacement by shock and vibration.

4. Provide corrosion resistant drain pans under the battery cells for each section and level of batteries.

2.05 SIGNAL SYSTEM TRANSFORMERS

A. Voltage Taps: Transformers shall be provided with primary and secondary taps, and taps shall be brought to terminals mounted inside the transformer case. Equip transformers with NEMA ST 20 full capacity taps. Provide four 2.5 percent taps; two above and two below normal primary voltage.

B. Rating: Provide transformers capable of carrying the entire rated load plus 25 percent. Flux density shall be sufficiently below saturation at rated voltage to allow excitation by a minimum of 10 percent overvoltage.

C. Noise Level: Noise level shall not exceed limits set by local regulations, and shall not exceed 40 dB referenced to 0.2 mPa at a distance of 600 mm while operating at rated voltage and load as determined by NEMA ST 20.

D. Construction: Transformer shall be dry-type general purpose conforming to AREMA Signal Manual, Part 14.2.10.

2.06 SIGNAL SYSTEM RESISTORS

A. General:

1. Approved types of resistors shall be connected into track, line, and power circuits. These components shall be of such design and capacity that they will protect the equipment and provide positive and safe operation.

2. All resistors, other than those required for electronic circuits, shall be suitable for railway signaling circuits, and shall meet the applicable requirements of the AREMA Signal Manual, Part 14.2.15.

3. Resistors for electronic circuits shall meet the applicable requirements of the AREMA Signal Manual, Part 1.5.1.

2.07 SIGNAL SYSTEM ARRESTORS

A. General: Approved types of arrestors shall be connected into track, line, and power circuits. Components shall be of such design and capacity that they will protect the equipment. All arrestors shall be suitable for railway signaling circuits, and shall meet the applicable requirements of the AREMA Signal Manual, Part 11.3.

2.08 SIGNAL SYSTEM WIRING DEVICES

A. Terminal Blocks: Terminal blocks, other than those utilized for specific railroad applications, shall comply with NEMA ICS 4 and shall be UL 1059 listed. Terminal blocks shall be of the screw type with washer style head to accommodate terminals specified.

1. Base and inter-terminal barriers shall accommodate terminals for No. 8 AWG and smaller stranded copper wire connectors. The metallic parts shall be non-ferrous and corrosion resistant. Each assembly of terminal blocks shall be identified and shall be provided with 20 percent spare terminals with no fewer than two spare terminals.

2. Terminal blocks for control circuits which are or may become energized at contact wire potential, must be rated for 1 kV. Terminal blocks rated at only 600 V will not be acceptable for these circuits.

2.09 AC INVERTERS

A. Design Requirements: Ac inverters shall meet the following minimum requirements:

1. Ac inverter shall be model AEP-3000-P4, manufactured by Schaefer, or owner approved equal.

2. Provide inverter capable of operating with input voltage of 12Vdc, ±15% or 110Vdc.

3. Provide inverter with an output of 120Vac, 60Hz.

4. Clearly and permanently mark the inverter with the manufacturer's name, serial number, part or model number, and the input and output rating.

2.10 SOURCE QUALITY CONTROL

A. Codes: All equipment, enclosures, circuit breakers, switches, and fittings utilized in the distribution of 120 Vac and/or 240 Vac power within the Signal Systems shall comply with the applicable local codes and NFPA 70, unless specified or approved otherwise.

PART 3 – EXECUTION

3.01 GENERAL

A. General: Install the complete power supplies and distribution system, complete with hardware and connecting material, per the Contract Drawings. The complete system shall include ac breaker panels where applicable, batteries, wiring, conduit, couplings, fasteners, circuit breakers, resistors, and permanent identification.

3.02 SIGNAL SYSTEM INSTALLATION

A. Housings: Install all power equipment, including batteries, within the LRT signal housing/room/case, as shown on the contract drawings. The use of battery wells is not permitted.

B. Power Buses: Power buses for each energy level present in a rack shall be provided in that rack, including positive and negative energy, commons, and grounds. Rack power bus shall consist of strapped AREMA terminals installed on rack terminal boards and wired to each point as required.

C. Terminal Cover: Install insulating nuts on any AREMA terminal post which carries greater than 50 volts per the requirements of Section 34 42 40, Signal Equipment Housings.

D. Grounding: Ground all power distribution components and enclosures.

E. Wiring and Conduit: Install conduit and wiring per the requirements of Section 34 42 20, Signal External Wire and Cable.

F. Identification: Identify all power distribution equipment and buses per the requirements of Section 34 42 22, Signal Internal Wiring.

G. Shipping: Ship batteries to the worksite dry.

H. Fuses: Provide fuses for energy loop distribution and distribution to each type of equipment, as identified on the Contract Drawings. Fuses shall be of suitable capacities to protect wiring and equipment from the effects of short circuits or overloads. Calculate and provide fuse ratings so that the closest fuse in the circuit upstream to a short circuit will be the fuse that interrupts.

3.03 SIGNAL POWER DISTRIBUTION

A. Feeders: Size all feeders to handle 150 percent minimum of the full load. Provide GRS conduit for ac wiring from the supply transformers to the housing/room/case breaker panel, if not already provided by the preceding Facilities contract, and from the breaker panel to the power supplies (or to the overhead cable tray if so routed).

B. Labeling: Provide labels for the breaker panels on the inside of the ac breaker panel door identifying the equipment supplied.

C. EMC Wire Routing: Distribute ac wiring routed through the overhead cable tray in twisted pairs. Separate ac wiring from Communication wiring installed in the cable tray. Provide additional EMI reduction hardware or special cable routing techniques in the power distribution if required.

D. Energy Backfeeds: Design circuits such that sneak path or back feed path connecting dc energy from one fused rack bus to another fused rack bus does not exist. Removal of a fuse shall leave that bus isolated from energy. Add blocking diodes where necessary.

E. Line Circuit Fuses: Provide fuses for the energy feed to each dc circuit leaving the signal housing/room/case.

F. Battery Disconnect: Provide test link disconnects for each battery bank. Isolate both the positive and negative battery connection through the disconnects.

3.04 GROUNDING

A. General Equipment Grounding: Power supply equipment and racks shall be grounded to the main signal house ground bus per Section 34 42 42, Grounding. A power source neutral lead shall not be used as a ground. If no acceptable ground is available within a building or structure, then ground rods shall be driven and a ground bus provided within the building or structure.

B. Power Supply Grounding: The safety ground for all power supplies shall be bonded to the signal shelter's main ground buss, per Section 34 42 42, Grounding.

3.05 SIGNAL SYSTEM TESTING

A. Power Distribution: This test shall verify that energy at all required levels is available in signal rooms, houses, and cases, and that it is properly distributed to equipment requiring power. The test procedure shall be divided into two sequential test sections (energy off-tests and energy-on tests), and shall verify that:

1. All power wiring has been correctly installed. Correct wiring shall be indicated on the approved Location Plans by marking with a green pencil.

2. No ground, short circuits, open circuits, crosses, or misplaced wiring exists in the power distribution system.

3. Output of ac power supplies correct voltage levels; record voltages and equipment serial numbers.

4. Output of dc power supplies correct voltage levels at correct polarity; record voltages, loads and equipment serial numbers.

5. Output of batteries are at correct voltage levels and correct polarity; record voltages.

6. Power indication and alarm circuits are operating properly. Correctly operating circuits shall be indicated on the approved Location Plans by marking with a green pencil.

7. Where contact verification is required, conduct testing as described in the Circuit Breakdown test specified in Section 34 42 95, Signal System Testing.

8. Power equipment and wire tags are in place and have been verified.

3.06 FIELD QUALITY CONTROL

A. Quality: The quality of the wayside signal system installation shall be ensured through the performance of tests and inspections made during the progress of this Contract and after completing the installation of equipment. Perform field installation inspections to ensure that all equipment furnished under this Contract is installed in compliance with the technical specifications.

END OF SECTION 34 42 41

SECTION 34 42 12

GROUNDING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. This Section includes the requirements for furnishing, installing, and testing complete grounding and bonding systems.

1.02 REFERENCED STANDARDS

A. American Society for Testing and Materials (ASTM):

1. C653 Standard Guide for Determination of the Thermal Resistance of Low-Density Blanket-Type Mineral Fiber Insulation.

2. D5 Standard Test Method for Penetration of Bituminous Materials.

3. D149 Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.

4. D257 Standard Test Methods for DC Resistance or Conductance of Insulating Materials.

5. D570 Standard Test Method for Water Absorption of Plastics.

B. Institute of Electrical and Electronic Engineers (IEEE):

1. 81 Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.

C. National Fire Protection Association (NFPA):

1. 70 National Electrical Code.

D. Underwriters Laboratories Inc. (UL):

1. 467 Grounding and Bonding Equipment.

1.03 QUALITY ASSURANCE

A. The Work of this Section shall meet the codes and regulations of the jurisdictional authorities, and all referenced standard.

B. Each item shall be UL-listed, unless otherwise approved.

1.04 SUBMITTALS

A. Signal Shelter Grounding: Submit grounding installation plan for signal shelters, showing locations of ground rods, wire forming ground grid, and connections to signal shelter.

B. Grounding Test Reports: Submit reports verifying ground grid resistance does not exceed specified values for each location, per the requirements of Section 34 42 95, "Signal System Testing".

1.05 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 – PRODUCTS

2.01 GROUNDING AND BONDING EQUIPMENT

A. General: Requirements shall be per UL 467.

B. Ground Grid:

1. Ground grid resistance to earth will not exceed 15 K.

C. Signal Shelter Grounding:

1. Provide 4 ground rods per the requirements of the signal house grounding plan, as shown on the contract drawings. Ground rods shall be ¾ inch diameter and 10 feet long, with a minimum of 10 mils copper cladding thickness.

2. Provide 6 inch x 6 inch hard-drawn pure copper ground bus plates in the case to serve as Earth Ground for all signal equipment. Provide additional ground plates if the design so requires.

3. Rods shall have a chamfered top to prevent mushrooming.

4. Provide all miscellaneous materials and tools required to ensure grounding is completed.

5. Provide a ground well for each ground rod, to access the rod for inspection or repair.

6. Ground grid shall be connected to ground rods by exothermic welds. Welds shall be Cadweld “One Shot” welds, as manufactured by Erico, or “owner approved equal”.

D. Ground Plates:

1. Provide a 6 inch by 6 inch hard drawn pure copper ground bus plate in the signal shelter to serve as Earth Ground for all signal equipment. Attach the ground plate to the signal shelter Earth Ground grid.

2. Provide a ground system for all Signal System equipment requiring grounds. Provide individual connections for all racks and equipment.

E. Exothermic Welds:

1. Welding material shall consist of copper exothermic mixture employing tin-metal in an amount to effectively constitute 4.5 percent to 5.5 percent of the resulting weld metal. The resulting weld metal shall be of high electrical conductivity and shall have a minimum tensile strength of 270 MPa (39,000 psi).

2. Coating Materials for Thermite Welded Connections: Use black, rubber based compound coating materials, which are soft, permanently pliable, moldable, and unbacked, not less than 3 mm (1/8 in.) thick, with properties as follows:

   a. Solids: 100 percent.

   b. Density: 1.4 kg/L (12.0 lb./gal.) minimum.

   c. Penetration: 90-130, ASTM D5.

   d. Water Absorption: 0.10 percent maximum, ASTM D570.

   e. Dielectric Strength: 500 V/25 µm (V/mil), ASTM D149.

   f. Volume Resistivity: 2000 MK in., ASTM D257.
      5000 MK·cm, ASTM D257.

   g. Service Temperature: -40ºC to +71ºC (-40ºF to +160ºF).

   h. Chemical Resistance: (ASTM Melting point, none; flammability, slow burning C653); resists alcohol, water, aqueous hydrochloride and sodium hydroxide; dissolved by carbon tetrachloride, naphtha gasoline, mineral, spirits, ketones, and benzene.

   i. Highly cohesive and adheres strongly to metals and adhesive concrete and to itself.

F. Grounding Conductors:

1. Grounding electrode conductors:

   a. Shall be insulated stranded copper conductor.

   b. Size unless otherwise indicated:

      1). For connecting ground rods and connecting grid to signal case, #2 AWG bare stranded wire.

2. Equipment grounding conductors:

   a. Equipment grounding insulated conductor: Single conductor stranded copper.

3. In Signal Housings/Rooms/Cases, ground wire for any equipment connected to a ground bus shall be minimum #6 AWG insulated, stranded, unless indicated or specified otherwise.

4. In Signal Housings/Rooms/Cases, ground wire for connection between ground rods and signal housing shall be #2 AWG bare, stranded. Ground wires from ground grid to signal shelter shall be routed through the inside of the shelter, to prevent vandalism or theft.

G. Terminal Lugs:

1. For #4/0 AWG and smaller conductors: Copper compression terminal lugs.

H. Ground Connector:

2. O-Z Gedney, Type KG or approved equal.

3. Two-piece, designed for connecting grounding conductor to bus bar.

4. Copper alloy body and silicon bronze bolt, nut and washer with interlocking clamp.

5. Exothermic weld: Size and type per manufacturer's recommendations.

PART 3 – EXECUTION

3.01 GROUNDING

A. Ground Connections:

1. Splices of grounding conductors are not permitted.

2. Ground connections to the track rails, or use of the neutral conductors of the local power company feed, is not permitted.

B. Grounding for Personnel Safety:

1. For wayside metal equipment including, but not limited to, cabinets, poles, pullboxes, equipment enclosures, and junction boxes, bond and ground each item using #6 AWG (minimum) copper conductor to one or more ground rods to provide 15 K or less resistance to ground. Wayside metal equipment on a bridge or tunnel structure should be attached to the structure or structure ground system using a minimum of #6 AWG (minimum) copper conductor.

C. Ground Rods:

1. Ground rods shall have grounding wires attached 4 inches above grade to facilitate inspection. Drive rods within 6 inches of the equipment being grounded, unless specified otherwise, in a location that does not create a tripping hazard. All connections shall be made by an approved exothermic weld process.

2. Provide a ground well for each ground rod, to access the rod for inspection or repair.

D. Signal Shelters: Ground shelters as shown on contract drawings.

E. Signal Racks:

1. Ground internal signal equipment, as shown on the contract drawings, to its respective rack.

2. Each rack shall be electrically isolated from the signal shelter and other equipment, and individually connected to the shelter's main ground buss.

3.02 TESTING

A. Signal Shelters: Inspect and test equipment grounds. The test shall be made as soon as the grounding system has been established and before testing commences. The test shall ensure that:

1. The grounding system is in place and correctly installed.

2. The measured resistance between earth ground and the wayside equipment ground does not exceed 15 Ω. Chemical treatment or other artificial means shall not be used to enhance resistance measurements. If the resistance exceeds 15 Ω, install additional rods.

3. Ground connections are tight, free of paint, and suitably protected from physical damage and corrosion.

4. Ground leads are sufficiently heavy, short, and direct.

5. The resistance from each ground connection to the ground bus is recorded.

6. Grounding equipment and wire tags are in place and have been verified.

7. Ground loops are intact and have been run to the equipment indicated on the plans.

B. Test Reports: Prepare and submit test results to the Resident Engineer.

3.03 FIELD QUALITY CONTROL

A. To meet resistance requirements, if the ground grid exceeds requirements, Contractor shall work with the Resident to resolve the issue. If resistance requirements cannot be met for a ground system installed by Contractor, Contractor shall drive additional ground rods, reinstall ground connections or install ground cable of a heavier gauge.

B. Perform quality assurance checks and inspections of installed equipment and ground connections for conformance with contract requirements and workmanship standards.

END OF SECTION 34 42 42

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SECTION 34 42 43

SIGNAL SYSTEM MARKING AND TAGGING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. This Section describes includes he requirements for marking and tagging wire and cable, and the identification of equipment and electrical components provided in this Contract.

B. This Section also includes the requirements for wayside signs to be provided in this Contract.

1.02 REFERENCED STANDARDS

A. American Railway Engineering and Maintenance of Way Association (AREMA):

1. Part 10.4.1 Recommended Instructions for Wire and Cable Installation and Maintenance.

2. Part 14.6.1 Recommended Design Criteria for Signs Other Than for Railroad-Highway Grade Crossings.

1.03 SUBMITTALS

A. Power Switch Machine Identification Product Data: Submit material data and drawings for switch machine identification numbers, closed point letters and power switch "Danger" sign. Include material data, and drawings indicating proposed sign sizes, lettering sizes, and styles.

B. Housing and Case Sign Product Data: Submit the proposed signs for housings and cases. Include material data, parts lists, and drawings indicating sign size, lettering size, and styles, and method of affixing to housing and case. In addition to the housing location sign, include crossing street identification sign if it is to be placed on the housing.

C. Tag and Marking Product Data: Submit tag and marking product data, including the following:

1. A sample of each type of marking and tag. Samples shall show typical nomenclature and lettering arrangement for each type of device, cable, wire or other item to be marked or tagged. Samples of signs are not required, unless specifically requested by the Resident Engineer.

2. Plans, diagrams, or photographs showing where each type of sign, marking, or tagging, will be applied.

3. Procedures for the application of marking or tagging which require special manufacturing or installation techniques, and methods of attachment to equipment.

1.04 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 – PRODUCTS

2.01 EQUIPMENT

A. Nameplates:

1. Electrical components shall be permanently marked to the lowest level of repair and replacement with part number identification which coincides in all cases with the latest manufacturer's data. Nameplates shall be provided on major equipment items with adequate space for the addition of VTA identification numbers by Contractor, as directed by the Resident Engineer.

2. Provide a permanent nameplate on each item of service connected or power operated equipment. Indicate the manufacturer, product name, model number, serial number, capacity, speed, ratings and similar essential operating data.

B. Switch Machines:

1. For each standard power switch machine, provide a number to identify the switch machine number. The number shall be white, 3 inch minimum, malleable metal numbers for attachment to the top of the switch machine housing, to indicate the number of the switch machine.

2. For each embedded power switch, stencil the switch number on the switch spring cylinder, and on the embedded switch metal cover plate. Coordinate size, lettering, and placement with the Resident Engineer. For each embedded power switch, also provide the high voltage warning sticker recommended by the manufacturer.

3. For each standard power switch machine, provide a letter to identify the normal position of the switch. The letter shall be a black, 6 inch malleable metal letter "N" for attachment to the top of tie on the gauge side of the normally closed point.

4. For each VTA-furnish spring and Contractor-provided embedded power switch, stencil the letter "N" to identify the normal position of the switch. Coordinate size, lettering, and placement with the Resident Engineer.

5. For each standard power switch, provide a metal sign which reads "Danger - Switch May Move at Any Time." Coordinate size, lettering, and sign placement with the Resident Engineer.

6. For each ballasted switch position indicator, provide identification number on indicator, visible to train operator.

C. Signal Housing and Case Signs:

1. Provide nameplates for each new signal shelter which indicate the location and number designation of the housing (ex: FIRST/KARINA SHB29), which conform to AREMA Signal Manual, Part 14.6.1, unless specified otherwise. The number associated with the housing or case, for clarification purposes, is based on milepost.

2. Provide LRT housing nameplates 5.25 in. x 22 in. x 0.125 in. thick, made of embossed sheet aluminum. Provide black lettering, Egyptian style lettering 2.25 in. x 1.5 in. centered in sign, on a white background. Provide two nameplates per housing, fastened by a strong durable, waterproof self adhesive, as recommended by the manufacturer. Locate the nameplates on the outside of housing where visible from the trackside. Coordinate sign placement with the Resident Engineer,

per the requirements of Section 34 42 09, "Signal Shelters".

D. Wire and Cable Tag Material:

1. Tags shall be white, laminated, vinyl or phenolic plastic type. The untreated tag base shall be milk-white and shall be capable of receiving characters without any blurring or fuzziness.

2. A laser jet printer, or owner approved equal, shall be the method of applying nomenclature to the base material. After lettering, a plastic overlay covering shall be applied to each side of the tag.

3. Identifying nomenclature shall allow for the display of three rows of lettering. Lettering shall not be less than 1/8 in. in height. Tags applied to entrance racks and backboards shall include nomenclature indicating terminal post and circuit designations.

4. All spare wires shall be tagged in numerical sequence (e.g., Spare-1, Spare-2).

2.02 QUALITY ASSURANCE

A. General: During factory acceptance tests, verify that the specified tags and markings are correct and applied in an approved manner.

PART 3 – EXECUTION

3.01 INSTALLATION

A. General:

1. Except as otherwise indicated for required labels and operating data, attach or imprint manufacturer's or producer's nameplates or trademarks on exposed surfaces of the products either in occupied spaces or on the exterior of the work.

2. Attach labels where required for observation after installation, on inconspicuous accessible surfaces in occupied spaces.

3. Locate nameplate on an accessible surface which, in occupied spaces, is not conspicuous.

4. Nameplates shall be attached at the center or center middle of the equipment, in a neat manner, depending on the space available, or as specified, using screws.

5. Drilling of concrete ties shall not be permitting where signs or nameplates are required to be so installed.

B. Switch Machines:

1. Attach the power switch machine identification number to the top of switch tie, on the field side. Face the identification number in the direction that allows it to be read by the vehicle operator.

2. Attach the switch machine normal point identification letter to the top of tie on the gauge side of the normally closed point.

3. For embedded power switches, stencil the switch number on the spring cylinder, and on the switch cover plate, as approved. Face the identification number in the direction that allows it to be read

by the vehicle operator.

4. Propose a location and method for mounting the powered switch danger sign and include as part of the switch machine installation layout drawing required in Section 34 42 25, "Power Switch Machines and Layouts".

5. For the power switch machine, indicate the switch numbers and letters on the switch machine installation layout drawing required in Section 34 42 25, "Power Switch Machines and Layouts".

C. Signal Case Signs: Install the number plates for each new case in accordance with the approved housing or case installation plan submittal.

D. Ballasted Switch Position Indicators: Install the identification number for each new ballasted switch position indicator in accordance with the approved switch position indicator product data.

E. SCADA Interface Equipment Marking: Event recorders/system monitoring units, vital microprocessors, TWC interrogators, and their modems shall be labeled in the same format as that used for labeling SCADA. Coordinate specific nomenclature with the Communications System design.

F. Wire and Cable Tag Application:

1. Unless otherwise specified, sleeve tags are to be used to permanently identify both ends of individual cables conductors that terminate in the signal housing/room/case, junction boxes, switch mechanisms, entrance racks and any equipment of the signal system outside of such locations. Unless otherwise specified, permanently identify both ends of all interior wire and cable conductors by a sleeve tag, with the exception of solid wire utilized for wirewrap applications. Apply nomenclature in accordance with the manufacturer's instructions in a permanently bonded and legible identification.

2. Flat tags shall be used to permanently identify cables at entrance boards, vital relay plug-boards, transformers, resistors, reactors, terminals, and all other components within the signal housing/room/case and all types of junction boxes. Entrance rack tags shall indicate terminal post identification on the top line and the functional nomenclature on the bottom line. Identify terminal post terminal post by geometry coordinates (e.g., rack, row and post number).

3. Cable tags shall be either wraparound or sleeve type tags. The tags shall contain the number and size of conductors, and origin and destination of the cable. Include cable numbers, where so identified.

G. Wire and Cable Tags:

1. Both ends of each cable, each conductor in each cable, and all terminated conductors and equipment in the signal housing/room/case, and each junction box, switch mechanism, circuit controller, and any signal system equipment outside of such locations, shall be permanently identified with a tag. All tags shall be installed so that they may be read with a minimum of disturbance of the tags or other equipment.

2. Tagging for wire and cable shall conform to AREMA Signal Manual, Part 10.4.1.

3. Tag all cables in a manner that is easily readable and not blocked by other cables or equipment.

4. Tag all wire terminations with permanent, waterproof, pre-typed, plastic laminated tags. Termination tags shall contain circuit and terminal nomenclature as identified on the approved location plans.

5. Cable and wire tags attached to event recorders/system monitoring units, vital microprocessors, modems, and other equipment interfacing to the Communications System shall use the same nomenclature as SCADA to identify what the cable or wire is attached to.

3.02 FIELD QUALITY CONTROL

A. Inspections: During routine field inspections and testing, verify that the field-installed tags and markings are correct and applied in an approved manner. Work shall not considered complete until tags and markings are correct and in place.

3.03 PROTECTION OF BALLAST

A. Contamination: Take all of the necessary precautionary measures to ensure that track ballast is not fouled (contaminated with dirt or sub-ballast) during the course of its work. Minimize any disruption to the ballast after it has been dressed the preceding facilities contracts and re-dress any ballast which has been disturbed.

END OF SECTION 34 42 43

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SECTION 34 42 95

SIGNAL SYSTEM TESTING

PART 1 – GENERAL

1.01 SUMMARY

A. This Section describes includes the requirements for signal testing provided in this Contract.

1.02 REFERENCED STANDARDS

A. American Railway Engineering and Maintenance of Way Association (AREMA):

1. Part 2.4.1 — Recommended Instructions for Inspection and Test of Signal Installations Before Placing in Service

2. Part 2.4.5 — Recommended Instructions for Electric Locking

3. Part 2.4.10 — Recommended Instructions for Interlockings

B. California Public Utilities Commission (Cal. PUC):

1. G.O. No. 75-D — Regulations Governing the Protection of Crossings at Grade of Roads, Highways and Streets with Railroads in the State of California

2. G. O. No. 143-B — Safety Rules and Regulations Governing Light-Rail Transit

C. Federal Railroad Administration (FRA), Code of Federal Regulations:

1. Part 234 — Grade Crossing Signal System Safety

2. Part 236 — Rules, Standards, and Instruction Governing the Installation, Inspection, Maintenance, and Repair of Signal and Train Control Systems, Devices, and Applications

1.03 SUBMITTALS

A. Factory Acceptance Test Plan: Submit factory acceptance test procedures and forms for all factory testing.

B. Field Acceptance Test Plan: Submit field acceptance test procedures and forms for all field testing, including static testing, operational testing, and dynamic testing.

C. Test Results: Submit completed test forms for all testing performed, including factory, field and in-service tests.

1.04 MEASUREMENT AND PAYMENT

A. Measurement: Signal System Testing shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Signal System Testing shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in this Section, complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 TEST EQUIPMENT

A. Test equipment and meters shall have been calibrated no more than 180 days prior to testing or in accordance with the equipment manufacturer's recommendations, whichever is the shorter time period.

PART 3 – EXECUTION

3.01 FACTORY ACCEPTANCE TESTING

A. General:

1. Signal houses and cases shall receive a complete circuit breakdown test before shipment. All external equipment and cabling which is to be connected to the case shall be simulated for these tests. Each circuit shall then, with the circuit energized, have each circuit break point individually opened by hand to determine that the controlled device becomes de-energized with the circuit opened and re-energized when the test opening is recessed. The stamped circuit test plans shall be marked at the time of the test, to indicate the checks made, in accordance with the approved test plan. The test shall verify that:

    a. Each circuit is tested for correct operation and response to each contact of each circuit element.

    b. When parallel paths exist, each path is correct and is energized from the same fuse. Circuits shall be disconnected to ensure a proper test.

    c. Each circuit is tested by simulating operating conditions to ensure that the circuit operates in accordance with the circuit design. This shall be done by verifying each contact in that circuit and verifying that the appropriate relay drops, or applied voltage is lost.

    d. Correct wiring shall be indicated on the approved Location Plans by marking with a green pencil, and verification of each individual contact shall be indicated by marking that contact with a contrasting colored pencil.

    e. Equipment and wire tags are in place. Discrepancies shall be tagged with a red paper tag fastened to the wire or device with a string.

    f. Fuse ratings and resistor sizes are correct.

    g. Terminations at both ends of each wire are solidly applied and are properly seated.

    h. Wiring of circuit elements are correct, including but not limited to, relay coils, relay test posts, terminals, and plug couplers. Each termination shall be checked to ensure properly applied terminals and that no extraneous connections exist. Correct elements shall be indicated as such by marking the approved Location Plans with a green pencil.

    i. Coordinates for all terminations and circuit elements have been verified.

2. Racks:

   a. Rack equipment shall be tested, per the approved factory test procedure, as a complete functional assembly, before shipment. Simulate, to the greatest degree possible, the final configuration of the room equipment to be installed on the job site.

3. Equipment not required to undergo a function or circuit breakdown test shall receive a complete point-to-point wire ring-out test before shipment. Each wire and cable conductor shall be individually checked with a ringer or buzzer to identify its two ends, the tagging checked for conformity with circuit plans and the exact termination points (relay name and contact number, terminal number, and equipment binding post) compared with that shown on the circuit plans. The stamped circuit test plans shall be marked at the time of the test, to indicate the checks made, in accordance with the approved test plan.

4. Certified test reports shall be submitted to the Resident Engineer before shipment, showing successful completion of each test.

5. Wiring and connections shall be tested for continuity and grounds before equipment is installed. When directed by the Resident Engineer, tests shall be made to demonstrate the insulation resistance of any selected circuit or group of circuits. Before energizing the system, a check shall be made of relays and instruments for proper operation. Test procedures, conduct of test and documentation of test results shall be in accordance with the Resident Engineer's specific instructions.

3.02 FIELD ACCEPTANCE TESTING

A. Field Acceptance Testing, General: Field acceptance tests shall include exercising of each system function through its required operations, including the imposition of simulated conditions, to prove that the installation complies with specified requirements. The following general requirements apply to equipment installed within housings and cases, as well as the testing of wayside equipment controlled from them. While identified as field acceptance tests, some tests may be performed in the factory, if approved by the Resident Engineer in accordance with approved test plan, providing such testing meets the requirements herein. While the descriptions of some tests are based on relay-based logic, corresponding tests are to be verified for all microprocessor-based systems, where applicable.

1. Field acceptance tests shall be conducted in compliance with approved plans and procedures.

2. Field acceptance tests shall be conducted using all pertinent circuit and arrangement (including signal case) plans to perform such tests. The approved Location Plans shall be updated continually to reflect as-installed conditions. Modifications or corrections shall be indicated on the field test copy of Location Plans by marking additions with a red pencil. Any and all changes shall be initialed and dated on the drawings by the test engineer. The original field copies shall be turned over to the Resident Engineer as part of the completion process.

3. Field acceptance tests shall include exercising of each system function through its required operations, including the imposition of simulated conditions, to prove that the installation complies with specified requirements. Furnish certified test reports for field acceptance tests. Where simulated conditions have been used to complete a test, indicate as such on the approved Location Plans.

4. Provide equipment and apparatus required for the tests, calibrated and in working order, at the test site before start of the test.

5. Reconnect wiring, remove jumpers, and generally restore equipment to operating conditions when tests are complete.

6. All instruments used in testing shall bear a record of calibration against certified standards. Such calibration shall be made at least every 180 days. Each test record shall identify the specific instrument used in the test and the date the instrument was last calibrated. The Contractor shall submit a copy of the certificate of calibration for each instrument along with the test reports. Test reports will be filled out in the field and signed and dated by the Contractor's test engineer, or quality engineer, and by the Resident Engineer (if witnessed). The Contractor shall submit all original test forms to the Resident Engineer.

3.03 STATIC TESTING

A. Static Tests:

1. Pre-Test Inspection:

a. Before starting static testing, with the exception of cable testing, equipment ground testing, and power bond testing, notify the Resident Engineer in writing at least 2 weeks before commencement of testing, that the Contractor is ready to begin testing.

b. Conduct a visual inspection to verify that all equipment has been installed and is ready for test. Utilizing the arrangement drawings, verify that all equipment tags are correct, including track circuit equipment, fuses, and entrance rack terminals, and indicate as such with a green pencil on the approved Location Plans.

2. Grounding: Test per the requirements of Section 26 05 26, Grounding.

3. Power Distribution: Test per the requirements of Section 34 42 41 Power Distribution Batteries and Chargers.

4. Circuit Breakdown:

a. All circuits which span housing locations, that could not be tested as a complete system in the factory, shall receive point-to-point wire ring-out and circuit breakdown tests after installation in the field. The factory-wired housing/cases, if completed and documented at the factory as having received a complete circuit breakdown, need not be repeated on-site, provided:

1) Contractor attests in writing that there have been no changes in the wiring after completion of the factory tests.

2) Contractor furnishes the checked-off circuit plans as required herein.

b. When required, the test shall meet the requirements specified herein in factory test.

c. Circuits modified after breakdown shall be verified one contact or break beyond the modified portion of the circuit.

5. Crossing And Wayside Equipment: Perform static testing of individual crossing and wayside components per the requirements of their respective sections.

3.04 OPERATIONAL TESTING

A. Operational Tests: Verify the proper operation and safety of the Signal System for all routes. While the following tests are based on relay-based logic, corresponding tests are to be verified for the vital microprocessor. Perform the following tests, at a minimum:

1. Line Circuit Checkout: Check the integrity of line circuits from location to location in order to:

   a. Verify line repeater relay circuits.

   b. Verify vital serial links between interlocking microprocessors.

2. Interlocking Operational Test: Verify that:

   a. Switch operating and correspondence circuits operate properly.

   b. Switch locking circuits operate properly.

   c. Detector locking of switch machine operates properly, including loss-of-shunt protection. Record time settings and verify proper timer operation.

   d. Route locking operates correctly for each track on each route through the interlocking.

   e. Approach locking operates to hold switches locked when a cleared route is canceled for each approach track. Verify and record the timer settings.

   f. The signals operate properly and correspond to the route and aspect charts and tables, including light out circuitry if used. Verify in the field that the proper signal aspect is displayed for each route. Verify that the necessary conditions for a route (e.g., track occupancy, traffic, switch position, route locking, gate down) are correct before the route clears.

   g. Route security circuits function properly by clearing a route and then falsely energizing the route relays for all opposing and conflicting routes. Verify in the field that the signal displays the stop aspect.

   h. Automatic (advanced) routing operates correctly from the TWC loop requests.

   i. All routes can be established and canceled from the local control panel, from OCC, and the TWC loops, as applicable.

   j. Mode control operates properly.

   k. Opposing or conflicting routes do not affect established routes.

   l. Parallel routes align and do not affect established routes.

   m. All other indications and controls operate properly.

   n. When an interlocking is within the highway crossing approach limits, verify that:

      1) Selection logic for the crossing activation checks occupancy of all routes through the interlocking.

2) Train overrun of the red signal shall cause the crossing warning devices to activate immediately.

3) Signal clearing requests cause the warning devices to activate the crossing, where applicable.

4) Delayed-on timers operate as designed. Make any final adjustment necessary to provide a safe and efficient system.

3. Battery Backup and Discharge Test: Verify that the system operates properly on battery, with the AC feeds shut off, for the required 8 hours, and that the batteries are recharged in 8 hours after power has been restored.

4. SCADA Interface Test: Testing shall be coordinated with SCADA contractor perform SCADA system changes:

a. Verify that all controls and indications, on a point by point basis, are being sent to the field from OCC, or being received at OCC from the field, in order to ensure all wiring or programming is correct.

b. Verify TWC error detection and corresponding re-transmissions in data communication with the Central Control System.

5. Street Traffic Control Interface Test: Verify interfaces to highway traffic signals operate as designed and are received at the traffic controller interface. Record final timer settings where timers are used.

6. Crossing Activation Test: Verify crossing controller and associated timer settings operate as designed, and that crossing warning activation by LRT vehicles operates as designed. Record final timer settings.

3.05 DYNAMIC TESTING

A. Dynamic Tests: Perform the following tests with a vehicle:

1. Control Line Verification Test: Verify the control lines for all operating conditions, including diverging routes, call-ons, and reverse running.

2. Pre/Post Shunt Test:

a. Pre-shunt distance shall be measured, recorded, and verified to be within acceptable distances. Verify that pre-shunt does not occur across insulated joints.

b. Post-shunt distance shall be measured, recorded, and verified to be within acceptable distances. Verify that post-shunt does not occur across insulated joints.

3. Crossing Activation Test: Verify that all crossing activation and timers operate as designed. Adjust timer settings if required to provide a more operational efficient operation, as directed by the Resident Engineer.

4. Train-to-Wayside Communications Test:

a. Verify for each location that route requests and cancels have been properly executed.

b. Verify, at each near-side station stop, that crossing is activated when a request has been made, and released, after a time delay, when a cancel request has been made.

END OF SECTION 34 42 95

SECTION 34 42 96

SIGNAL SYSTEM SUPPORT

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes the requirements for manuals, training to be provided in this Contract. These manuals, and the training provided, shall provide VTA staff with the knowledge to operate, maintain, and expand the Signal Systems. This Section identifies the spare parts, test equipment, and tools to be supplied under this Contract.

B. Manuals: The manuals to be provided shall include:

1. Manufacturer's Operation and Maintenance (O&M) Manuals.
2. Custom-developed maintenance manuals, specific to VTA's Communications and Signal Systems and consistent with VTA's maintenance program.
3. Parts catalogs.

C. Training Program:

1. Training classes shall be conducted for both operation and maintenance of subsystems and equipment.
2. The training program for maintenance-oriented courses shall be oriented to train VTA staff in maintenance of the specific equipment and equipment configuration installed at VTA.

D. Spare Parts and Test Equipment:

1. Spare parts shall be provided as listed herein.
2. The contractor shall provide a list of additional recommended spare parts, and of recommended tools and test equipment, as described herein.

1.02 SUBMITTALS

A. Training Plans: Submit complete plans for providing Signal Systems training described herein. Each training plan shall include the following information:

1. A proposed schedule for each class.
2. Resumes of personnel proposed to be instructors for each class.
3. A statement of purpose of the training for each course.
4. A course syllabus for each course.

5. An overview of the hands-on experience to be included as part of each course, and a list of the equipment, tools and test equipment, manuals, and other materials to be utilized as student training aides and instructor aids.

6. A description of the pre-requisite knowledge for each course. The Contractor may assume each student has at least an AA degree, or has graduated from a technical school, or worked in a similar role that had been intended for the student.

B. Draft Training Course Description: For each course:

1. Submit a complete description for each course. The course description shall include, at a minimum, the following information:

a. A detailed outline of the material to be covered in the course and the duration, in hours, of the training for each major subject area within the course.

b. Copies of the visual aids, manuals, as-built documentation, and other printed materials to be used during the course.

c. Description of all other training aids, materials, tools and equipment.

d. Detailed descriptions of the procedures to be performed by students during hands-on training.

e. Specific pass/fail criteria for the course, including a sample test or assessment sheet, and a statement of the knowledge and skills students should possess at the conclusion of the course.

f. Description of Instructor materials, where applicable, (including a brief description of the contents of the Instructor Manual for the course).

g. Description of VTA-provided facility requirements and estimated time of use.

C. Final Training Course Descriptions: Submit the final course descriptions to be utilized for training.

D. Approved Training Course Descriptions: Submit 20 copies of the final approved course descriptions to be utilized for training.

E. Revised Training Material: Should any changes be required to the training course descriptions or training plans after performance of training, submit revised training material.

F. Manual Outlines and Style Guides: Submit a style guide for customized manuals which defines proposed formats (e.g., for pages, paragraphs, lists, and flow charts), fonts and types, VTA Communications and Signal System terminology, general manual and chapter organization, guidelines for including manufacturer materials, guidelines for referencing other materials, and methods for highlighting, presenting illustrations and drawings, and depicting procedures. For all standard manufacturer’s manual, submit, as a minimum, an outline in the form of a table of contents, detailed to indicate all major headings, major subheadings, tables, and diagrams, to be provided in the manual.

G. Draft Signal System Manuals:

1. Submit a draft version of each type of standard manufacturer’s Signal manual.

2. Submit a draft version of each type of customized Signal manual.

H. Final Draft Signal System Manuals: Submit a final draft of each type of Signal manual. Submit proposed bindings for final manuals, if different from that to be provided with the draft manuals.

I. Approved Signal System Manuals: Submit 3 hard copies and 5 electronic copies (CD-ROM) of each final approved Signal manual. The CD shall contain all material contained in the manuals, including photographs, drawings, and diagrams, and shall be formatted to read each page individually utilizing Adobe Acrobat. The format shall allow VTA to modify and upgrade the manual (including text, tables, and embedded drawings) using standard software tools in the Personal Computer - Windows environment.

J. Signal System Spare Parts Lists: Submit a detailed list of spare parts to be provided under this contract. Submit a list of recommended additional spare parts, in the same format as the list of parts provided. Submit a list of recommended tools and test equipment in the same format.

1.03 DEFINITIONS

A. Class: An instance of a course, typically provided to multiple students and consisting of multiple sessions. Each class shall cover the complete course syllabus of the associated course.

B. Course: A training unit covering a subject and with associated syllabus and course materials.

C. Instructor: The individual conducting the class (or who will conduct the class).

D. Replaceable Unit: Any physical unit (e.g., component, printed circuit board) which can be removed and replaced, and which removal and replacement of does not require removing soldering, re-soldering or re-wiring (other than disconnecting from/connecting to a wiring terminal) of that unit, nor of any other unit in order to access the unit. If a unit is not a replaceable unit and is not within a replaceable unit (as defined in the preceding sentence), the entire rack/cabinet (including that rack or cabinet's contents, e.g., equipment and wiring) within which the unit is situated shall be considered a replaceable unit.

1.04 MEASUREMENT AND PAYMENT

A. Measurement: Signal System Support shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Signal System Support shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in this Section, complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 MANUAL FORMAT

A. Cover Sheet: Assemble manuals using manufacturer's latest standard commercial data. Include the following information on the cover and on inside cover sheet:

(CONTRACTOR NAME AND LOGO)

(PUBLISHED MONTH AND DATE)

(TITLE OF EQUIPMENT OR FUNCTION)

OPERATION AND MAINTENANCE MANUAL

(VOLUME NUMBER)

(PROJECT TITLE)

(TITLE AND NUMBER OF CONTRACT)

Accepted: ____________________ for VTA

Acceptance Date: _____________

B. General Formatting Requirements:

1. Size: 8-1/2 in. x 11 in.

2. Paper: White bond, at least 20 lb. weight, high gloss paper.

3. Text: Printed or typewritten, and based on the font and format approved by the Resident Engineer.

4. Printed Data: Provide manufacturer's catalog cuts, brochures, operations, and maintenance data. Clear reproductions thereof will be acceptable.

5. Drawings: Provide 8-1/2 in. x 11 in., bound in with text. Drawings 11 in. by 17 in. shall be "Z" folded to open out clear of the main text, show the drawing title block. Larger drawings are acceptable, provided they are folded to fit into a pocket inside the rear cover of the manual. Reinforce edges of large drawings that are placed in the binder portion of the manual.

6. Prints of Drawings: Black on white, or color, if provided as such by the manufacturer, sharp in detail and suitable for making reproductions. Only professionally copied material will be accepted.

7. Flysheets: Separate each portion of the manual with colored, neatly prepared flysheets briefly describing contents of the ensuing portion.

8. Covers: Provide 40 mil to 50 mil clear plastic, front and back covers for each manual.

9. Bindings: Conceal the binding mechanism inside the manual. 3-ring, vinyl-covered, D binders are acceptable, subject to the Resident Engineer approval. Include pocket folders on the inside covers for folded information. Provide see-through covers on the front and spine of each binder to insert manual cover and identification in both.

10. Assembly: Assemble manuals using the manufacturer's latest commercial data. Manufacturer's pre-printed material may be incorporated within manuals, subject to the Resident Engineer approval. Materials and information not pertinent to VTA's Communications and Signal Systems shall not be incorporated.

11. Nomenclature: Maintenance manuals shall use nomenclature, symbols and designations common to those found and approved by such bodies as the AREMA, IEEE, and SAE, which are common to the USA workplace. References to supplemental information shall be included where necessary.

12. Provide all final approved manuals, catalogues, and parts list in electronic format (CD-ROM). The CD shall contain all material contained in the manuals, including photographs, drawings, and diagrams, and shall be formatted to read each page individually utilizing Adobe Acrobat. The format

shall allow VTA to modify and upgrade the manual (including text, tables, and embedded drawings) using standard software tools in the Personal Computer - Windows environment.

C. Contents of Manuals: In addition to the specific requirements noted for each type of manual, each manual shall contain:

1. An index of all volumes in each multiple volume systems.

2. An index in and for each volume. List and combine the literature for each system in the sequence of operation.

3. A sheet following the index, include subcontractors, by system, including:

   a. Name, address, and telephone numbers of Contractor, subcontractor, suppliers, and installers.

   b. Name, address, and telephone numbers of manufacturer's nearest service representative.

   c. Name, address, and telephone numbers of nearest parts vendors and service representatives.

4. Copy of guaranties and warranties issued to, and executed in the name of VTA.

5. Description of system and components parts.

6. Pre-operation testing or inspection lists and required tools and equipment.

7. Procedures for starting, operating, stopping equipment, and special warning or caution instructions.

8. Post-operation check or shutdown list.

9. Inspection and adjustment procedures.

10. Emergency operating, special warnings or caution instructions.

11. Preventative maintenance inspections or upper level testing schedules and procedures.

12. A copy of wiring diagrams for each major item of equipment pertinent to the manual, if not included in the specific system location plan sets.

13. An approved copy of the shop and layout drawing for each major item of equipment pertinent to the manual, followed by:

   a. Manufacturer's parts list with catalog names, numbers, and illustrations, with ordering information.

   b. An exploded view of individual components or pieces of equipment which require specific detailed information regarding operation or maintenance, with part designations.

   c. List of manufacturer's spare part, prices, and quantities required for two years of operation.

   d. List of special tools and test equipment required for operation, maintenance, adjustment, testing, and repair of the equipment or component.

e. Dismantling, disposal, and re-assembly instructions.

f. Calibration procedures.

g. Material ordering information.

14. Procedure steps and list elements shall be enumerated; each procedure which contains a conditional step (e.g., as a result of a decision) or branch shall also be depicted using a flow chart or similar method.

D. Parts Catalogs:

1. Renewal parts catalogs shall be provided separately, if not integrated into the applicable maintenance manual, and shall enumerate and describe every component with its related parts, including the supplier's part number, the Contractor's part number, and provisions for entry of VTA's internal tracking number.

2. Cut-away and exploded drawings shall be used to permit identification of all parts not readily identified by description. Parts common to different components, such as bolts and nuts, shall bear the same Contractor's number, with a reference to the other components in which they are found.

3. Each part or component shall be identified as being part of the next assembly. Commercially available items such as common standard fastenings, fuses, lamps, and fittings shall be identified by standard hardware nomenclature in addition to the Contractor's number. A separate list of these items shall be provided in the catalog with adequate information for ordering these items through commercial channels.

4. Include a complete itemization of all servicing materials (oils, paints, special compounds, and greases) required with components requiring their use.

5. Provide lists with all ordering and procurement information required for all components and subassemblies to the LLRU so there is no need for VTA to request information from the Contractor at any future date. These lists shall be reproducible and suitable for three-ring loose-leaf binding, and shall be adequately cross-referenced on the related drawings and the Bill of Materials.

6. The parts catalog shall include the following and any other information necessary for its efficient and effective use:

a. Parts indexed by subsystem.

b. Each subsystem assembly, LLRU, and part referenced to the lowest replaceable component level with its assigned part number and where applicable, the manufacturer's part number.

c. Exploded parts diagrams, illustrated parts breakdowns and schematic drawings to facilitate the description of parts and subassemblies, where applicable.

2.02 CUSTOMIZED MANUALS - GENERAL

A. Customized maintenance manuals, Control Supervisor user manuals and CCS system management manuals shall be provided. CCS user manuals shall use LRT operating terminology applicable to and correct for VTA operations.

B. Where applicable, customized manuals shall be tailored for the project to which it applies.

2.03 SIGNAL SYSTEM MANUALS

A. Maintenance Manuals:

1. Provide maintenance manuals with detail procedures for all aspects of Signal System servicing, adjusting, testing and repair. They shall cover all levels of maintenance from field adjustment, test and lowest level replacement unit (LLRU), shop adjustment, and overhaul and test of components or apparatus. The manuals shall contain systematic failure isolation procedures.

2. Standard manufacturer maintenance instruction may be used for individual components or equipment, but specific additional details shall be provided for the integration of overall system maintenance.

3. Maintenance manuals shall include:

    a. Power switch machine, each type.

    b. Wayside LED signal.

    c. Vital microprocessor system and associated equipment, including communications data server.

    d. Grade crossing controller.

    e. Crossing gate mechanism.

    f. Major power distribution equipment, such as rectifiers, chargers, and batteries.

    g. TWC equipment.

    h. Audio frequency track circuit.

    i. Relays, vital and non-vital.

    j. Event recorders.

    k. Local control panels.

4. The maintenance manual shall contain the following information and any additional information needed for both optimal preventive and optimal corrective maintenance functions:

    a. Comprehensive and comprehensible description of the subject and its usage. Provide drawings and figures as necessary to facilitate understanding of the equipment.

    b. Theory of operation.

    c. Expanded information relevant to the maintenance function.

    d. Complete and detailed schematic, wiring and block diagrams of all as-built systems and subsystems.

e. Detailed fault diagnosis procedures and flowcharts compatible with in-service maintenance so VTA's maintenance personnel can effectively service, inspect, maintain, adjust, troubleshoot, repair, replace and overhaul the components and subsystems.

f. Detailed routine preventive maintenance procedures.

g. A complete replacement parts list, in Bill of Material format with manufacturers' part numbers and name, indentured by system, subsystem, LLRU, and component level with required serial numbers.

h. Recommended sources for the procurement of components.

i. Complete and detailed installation, alignment and adjustment procedures. Provide a cross-reference to the applicable test procedures, where applicable.

j. Warranty and warranty administration information for each system, subsystem, and LLRU.

B. Operations Manual: Provide a manual describing the complete operation of the LRT Signal Systems from Alum Rock to Eastridge. The manuals shall contain the following information, as a minimum, and any additional information required for optimal use of the system:

1. General familiarization material, including location map, types of operations, and modes of control.

2. General function and operation of all major components, such as vital microprocessor, crossing controller, TWC, and audio track circuits. Include any pertinent drawings (as-builts) required to enumerate (e.g., housing layout).

3. Subsystem setup and shutdown procedures for abnormal operations, emergency operations, and preventative and corrective maintenance actions, where applicable.

4. General function and operation of all interfaces, such as SCADA, traffic control, and electrical power.

5. Provide in-depth descriptions of the highway grade and pedestrian crossing operations, providing specifics on a location by location basis, where necessary.

C. General: Provide in each manual, any safety-related cautions, special procedures, warnings, or other information needed to maintain safe conditions for the patrons, maintenance personnel, and equipment. Organize the manuals so that each major subsystem is treated as an integrated system and not as a grouping of dissociated parts. Provide block diagrams, signal flow diagrams, functional schematics, functional wiring diagrams, exploded views, and illustrated part breakdowns to facilitate descriptions of the assemblies and the relationships of components, subsystems and systems.

2.04 TRAINING COURSES - GENERAL

A. Instructor: Classes shall be conducted by instructors provided by the Contractor. For each class, the instructor shall have previously conducted a class of similar subject matter and scope, and shall be proficient in use of the tools, equipment, and instructor aids.

B. Students: Unless otherwise specified, each class will have approximately 12 students per class. In addition to those students, the Resident Engineer may authorize up to three additional personnel to observe any or all training sessions.

C. Materials:

1. Course materials (e.g., manuals, class hand-outs, tools, equipment, video tapes, computer-based software) shall be provided for each class, and shall be reusable (where practical), and shall become the property of VTA. Additionally, at a minimum, VTA shall be provided sufficient training materials to conduct two additional classes of each training course.

2. Information for each course period (with each course period more than four hours) shall define the objective of the course period; the instruction environment, tools, course materials; procedure-level use of course materials, tools, other instruction aids; alternative training approaches (to cater where materials are not producing the level of training intended); and methods and criteria to assess/determine student progress and proficiency. Information shall include instructions on use of course materials, tools, equipment and other instruction aids.

D. Location: Training will be held at a VTA location. VTA will provide necessary seating, lighting, and related facilities.

E. Emphasis: Courses shall emphasize hands-on training, using Signal System equipment, tools, test equipment, and documented procedures, as applicable. Equipment and instruction aids shall be used to illustrate information and procedures in corresponding manuals.

F. Maintenance Course Goals: Maintenance training shall provide maintenance personnel with the knowledge (of the related subsystem) and skills required to:

1. Gain a thorough understanding of the operation of the system, subsystem, and equipment.

2. Gain an understanding of the technology, architecture, and specific configuration.

3. Gain familiarity with the specific components and their role.

4. Gain familiarity with drawings and other design and installation documentation.

5. Gain familiarity with and use procedures in the corresponding maintenance manuals.

6. Be adept at using all tools, test equipment and built-in diagnostics and monitors.

7. Be adept at performing preventative maintenance.

8. Be adept at performing first level maintenance (to the Field Replaceable Unit), including:

   a. Using Communications System facilities, tools and test equipment to efficiently recognize problems, troubleshoot equipment in the field, isolate the problem, and determine units which have failed or are operating incorrectly.

   b. Removing failed or incorrectly operating equipment from service safely and with minimal impact on continued operation of the Communications System.

   c. Capturing and recording supporting diagnostic data to help further troubleshooting of the FRU.

   d. Planning and implementing temporary workarounds.

e. Ensuring candidate replacement units are operating correctly, and have correct settings.

f. Installing replacement units safely and correctly, checking that the replacement unit is operating correctly, and introducing the replacement unit into the operating Communications System with minimal impact on the operation of the Communications System.

9. Be adept at performing shop maintenance (to the Lowest Level Replaceable Unit), including:

a. Using Communications System facilities, tools and test equipment to efficiently isolate the problem within the subject FRU, troubleshoot, and determine which replaceable unit has failed or is operating incorrectly.

b. Removing replaceable units from the field replaceable units.

c. Capturing and recording diagnostic data.

d. Coordinating with manufacturer's support staff and information centers as needed, including actions such as downloading, installing and testing new firmware.

e. Rebuilding, configuring and verifying correct operation of higher-level replaceable units, up through and including field replaceable units.

G. Completion:

1. Training classes shall be repeated, if in the opinion of the Resident Engineer, the training provided is inadequate and does not meet the goals of the training course and the requirements of these technical specifications.

2. Each type of training shall be completed prior to the need for VTA staff to perform the functions associated with that training.

H. Taping: VTA shall be given the opportunity to video tape all training sessions for their own use.

I. Training Schedule: Schedule is to accommodate VTA's operation and maintenance of the installed systems and equipment. Training shall not start until the training program, lesson plans, and all required material has been approved, and all required copies have been received by the Resident Engineer. Unless otherwise specified, each training class shall be held on consecutive days, excluding weekends and holidays. Each day of training shall be for eight hours unless otherwise specified.

2.05 SIGNAL SYSTEM SPARE PARTS

A. General:

1. All spare parts and consumable materials shall be identical to the equivalent installed item and shall meet all requirements of the appropriate sections of these technical specifications. Parts availability shall be for a period of 7 years after the completion of the Contract.

2. All items supplied shall be complete and ready for installation, except for the wire and cable necessary for connection to external equipment.

B. Spare Parts and Consumable Materials Lists:

1. Required spare parts and consumable materials lists shall include the following information for each part:

   a. Contractor’s stock number.

   b. Price.

   c. Supplier and manufacturer’s part number.

   d. Name and address of supplier or manufacturer.

   e. Description.

   f. Assignment (type of assembly).

   g. Drawing reference number.

   h. Lead time for re-order.

   i. Frequency and reasons for replacement based on records.

   j. Each part of component identified as being part of next larger assembly or sub-assembly.

C. LRT Signal System Required Spare Parts: List and furnish the required spare parts and consumable materials identified in Table 1. Modify as required to match equipment actually utilized in the Contract.

TABLE 1

Quantity	Description
1	Wayside 3-aspect signal assembly with mast and base, complete
1	Wayside 4-aspect signal assembly with mast and base, complete
2	Lenses and lighting modules of each color provided
1	Switch and lock movement layout complete with junction box and all rods
1	Vital Microprocessor with Modules (two modules of each type provided)
2	Complete audio frequency track circuit transmitter
2	Complete audio frequency track circuit receiver
2	Audio frequency track circuit card of each type provided
2	Coded track circuits equipment
2	Impedance bond
1	Gate arm of each length provided
1	Set of gate arm lights
1	Flashing light crossing signal complete with mast and junction box base
1	Crossing Controller with Lighting/Surge Panel
2	TWC Interrogator (HCS-V) Card Cage
2	TWC Transceiver Card (HCS-V-RT)
2	TWC Multiplexer Card (HCS-R-MX)
2	TWC Multiplexer Card (HCS-V-MX)
2	TWC Relay Output Card (HCS-V-R-O)
2	TWC Loop Converter, Complete with Sealant
2	Relay of each type provided

Quantity	Description
1	Communications HUB
1	12V to 24V DC-DC Converter
1	Battery Charger
5	TWC Programming Software on CD-ROM

PART 3 – EXECUTION

3.01 SIGNAL COURSE - SIGNAL SYSTEM OVERVIEW

A. General:

1. Class length: 24 hours.

2. Number of classes: 2.

3. Each class may have up to 12 students.

B. Topics: A thorough explanation of the function of the Signal System and the basic safety principles involved, its various safety features and the basic levels of required maintenance. Emphasize the operational safety, capabilities, characteristics and limitations of the equipment, and the ability of the system to downgrade operations upon incidence of system failures and continue to operate in a reduced mode of operation. Also include emergency operating capabilities, and general training on making minor programming changes to VETAG and coded track circuit microprocessors (as an introduction to the subsequent detailed courses to be provided. Include interfaces with SCADA.

C. Course Goals: Class participants shall have a general understanding of the basic operational and safety features of the Hostetter Signal System, including its limitations and the general requirements needed to maintain its operation. The participants shall also be able to complete basic programming changes to the VETAG and coded track circuit microprocessors systems provided and understand what and how information is being transmitted and received from OCC via SCADA.

3.02 SIGNAL COURSE - SIGNAL SYSTEM OVERVIEW

A. General:

1. Class length: 8 hours.

2. Number of classes: 2.

3. Each class may have up to 12 students.

B. Topics: A thorough explanation of the function of the Alum Rock to Eastridge Signal Systems, and the basic safety principles involved, its various safety features and the basic levels of required maintenance. Emphasize the operational safety, capabilities, characteristics and limitations of the equipment, and the ability of the system to downgrade operations upon incidence of system failures and continue to operate in a reduced mode of operation. Also include emergency operating capabilities, and general training on making minor programming changes to TWC, vital interlocking microprocessors, crossing controllers, and event recorders (as an introduction to the subsequent detailed courses to be provided). Include interfaces with SCADA and street traffic control.

C. Course Goals: Class participants shall have a general understanding of the basic operational and safety features of the Alum Rock to Eastridge Signal Systems, including its limitations and the general requirements needed to maintain its operation. The participants shall also be able to complete basic programming changes to the TWC, vital interlocking, crossing controller, and event recorder systems provided. They shall be able to understand what and how information is being transmitted and received from OCC via SCADA and to street traffic controllers.

3.03 SIGNAL COURSE - SIGNAL SYSTEM MAINTENANCE

A. General:

1. Class length: 8 hours.

2. Number of classes: 2.

3. Each class may have up to 12 students.

B. Topics: Detailed instruction on all special maintenance functions required, including the items noted below. Special attention is to be given to instruction on devices or systems new to VTA's operation. Provide troubleshooting methodology training, including simulated conditions and situations. Emphasize the development of the ability to diagnose and counteract failures and unusual equipment responses.

1. Microprocessor operation, maintenance and adjustment.

2. Audio Frequency Overlay track circuit operation, maintenance and adjustment.

3. Wayside LED signal operation, maintenance and adjustment.

4. Power equipment operation, maintenance and adjustment.

5. Auxiliary systems (such as event recorder/system monitoring unit) operation, maintenance and adjustment.

C. Course Goals: Class participants shall have a thorough understanding of the maintenance functions needed to maintain signals, power equipment and the other auxiliary systems used on the signal systems. The participants shall understand the methodology in troubleshooting problems and be able to diagnose and counteract failures and equipment responses.

3.04 SPARES

A. General: The Contractor shall submit spares list with information as described in Article 2.05 of this Section and deliver to VTA at the Younger Yard Facility.

B. Delivery:

1. After selection by the Resident Engineer, deliver all spare parts, tools, and consumable materials to VTA's Power and Signal Division at 101 Younger in San Jose, as directed by the Resident Engineer. Pack all material for warehouse storage and clearly mark with manufacturer's part and/or style number.

2. Unload and store all items neatly in VTA's storage facility as directed by the Resident Engineer.

3. Complete delivery and storage of all spare parts, tools, and consumable materials no later than 60 calendar days prior to the Contract completion date.

C. Spare Parts Use: In the event that spare parts, tools, and consumable materials must be used in the course of satisfying warranty procedures, replace such items, in kind, within 30 calendar days, at no cost to VTA.

END OF SECTION 34 42 96

SECTION 34 54 00

AUTOMATED FARE COLLECTION SYSTEM INSTALLATION

PART 1 - GENERAL

1.01 SUMMARY

This Technical Specifications Section provides requirements regarding Fare Collection Equipment Related Installation Work, including:

A. Requirements for facility infrastructure related requirements (e.g., conduit, cable, racks, enclosures and related accessories) necessary to support installation of the Fare Collection System equipment.

B. Requirements for installation and testing support for Fare Collection System Equipment, including Ticket Vending Machines (TVM), VTA Clipper Card Readers (CCR or Card Interface Device (CID)), and all required related accessories.

C. The work includes installation of TVMs and CCRs at two passenger stations:

1. EBRC Story Station
    a. Station Platform
2. EBRC Eastridge Station
    a. Transit Plaza
    b. Station Platform

D. Install a total of five VTA TVMs. Install TVMs at three locations as follows:

1. Install two TVMs at the Eastridge Station West Entrance at the Transit Plaza.
2. Install one TVM on the Eastridge Station Platform, just north of the north passenger shelter.
3. Install two TVMs on the Story Station Platform at the entrance to the Station Platform, just north of the south platform staircase.

E. Install a total of five CCR. These CCRs are VTA Furnished Equipment (VFE). Install CCRs at three locations as follows:

1. Install two CCRs at the Eastridge Station West Entrance at the Transit Plaza, adjacent to the TVMs.
2. Install one CCR on the Eastridge Station Platform, just north of the north passenger shelter, adjacent to the TVMs.
3. Install two CCRs on the Story Station Platform at the entrance to the Station Platform, just north of the south platform staircase.

F. Furnish and install CCR 24 VDC power supplies, circuit breakers and other associated equipment needed for a complete interface between Eastridge and Story station Signal/Communications Rooms and the CCRs.

G. The work must include site preparation, conduit work, equipment anchoring and mounting, power and communications cable installation, grounding, connections and terminations, testing of all equipment and connections, and other features as required for a complete installation. Provide and install all features required for complete installations at all locations.

H. The work must include vendor (Ventek International Inc.) support during installation, and vendor shall provide continued support and integration services at the stations, at VROF, and at other locations necessary to provide a completely functional and tested system of TVMs and CCRs, including all features and functionality as specified, and that exist throughout the existing VTA LRT system.

1.02 RELATED SECTIONS

A. Section 27 05 28 – Pathways for Communications Systems

B. Section 27 11 16 – Communications Cabinets, Racks, Frames and Enclosures

C. Section 27 11 19 – Communications Terminal Blocks and Patch Panels

D. Section 27 13 00 – Communications Network Cabling

E. Section 27 15 00 – Communications Low-Voltage Conductors and Cables

F. Section 27 21 00 – Communications Network Equipment

G. Section 27 26 00 – Communications Programming and Integration Services

H. Section 27 42 19 – Public Address System

I. Section 27 42 20 – Passenger Information Monitor System

J. Section 28 20 00 – Video Surveillance (CCTV)

K. Section 28 40 00 – SCADA Monitoring and Control System

L. Section 34 54 01 – Automated Fare Collection System Procurement

1.03 REFERENCES

A. The latest versions of the following standards and references apply to the work included in this Section, in addition to those codes and standards common to all communications subsystems specified in section 27 05 00 “Common Work Results for Communications”. If a conflict must arise between various standards, the California state code amendments must govern, or the most strict/conservative requirement must govern.

B. American National Standard Institute (ANSI):

1. ANSI C2 National Electric Safety Code (NESC)

C. California Electrical Code

D. Electronics Industries Association (EIA):

1. EIA/ECA-310-E Cabinets, Racks, Panels, and Associated Equipment

E. National Electrical Manufacturers Association (NEMA):

1. NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum).

F. State of California Code of Regulations (Title 24)

G. Underwriters Laboratories, Inc. (UL)

1.04 SUBMITTALS

A. Product Data: Provide technical data, including list of equipment and material, manufacturer's descriptive and technical literature, and catalog cuts.

B. Provide installation drawings for equipment being installed.

C. 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 with product data attesting that the items furnished under this Technical Specifications Section conform to the specified requirements.

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. VTA will provide installation procedures for the TVMs.

E. Field Test Plan and Reports: Submit field test plan and reports in accordance with requirements indicated.

F. Record Drawings: Submit record drawings in accordance with requirements indicated.

1.05 ABBREVIATIONS

A. General:

1. CID Card Interface Device

2. CCR Clipper Card Readers

3. TVM Ticket Vending Machine

1.06 MEASUREMENT AND PAYMENT

A. Measurement:

1. Ticket Vending Machine Installation shall be measured by the individual unit (each).

2. Card Interface Device (CID, CCR) installation shall be measured by the individual unit (each).

B. Payment: The contract price paid per individual unit (each) for Ticket Vending Machine Installation and Card Interface Device (CID, CCR) installation shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in installing the Ticket Vending Machines and Card Interface Devices (CID, CCR) complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.01 TVM ANCHOR BOLTS

A. Provide anchors with:

1. 5/8 inch diameter HAS anchor rods
2. Employ capsule adhesive anchor system
3. Anchor rods must be stainless steel
4. Anchor rods must be 5” in length.
5. Anchor bolts must be Hilti HAS –R 304 SS anchor rods or approved equal.

2.02 CCR POWER SUPPLIES

A. Provide a 24 Vdc power supply for each CCR. CCR power supplies must meet the following requirements:

1. Full range AC input voltage: 90 to 295 Vac.
2. Max current: 4 A.
3. Max output power: 96 W.
4. Operating Temperature: Minus 22 degrees Fahrenheit to 150 degrees Fahrenheit.
5. Protections: short circuit / over current / over voltage / over temperature.
6. IP67 rated.
7. Metal enclosure.
8. Power supplies must be Meanwell DR-100-24 or approved equal

2.03 VTA-FURNISHED EQUIPMENT (VFE)

1. VTA will provide refurbished Bill Note Acceptors (BNA 57) and PIN Pads (from VTA spares) to be included in the fabrication/manufacture of the TVMs, delivered with the completed TVMs.

2. VTA will provide Clipper Card Readers (also known as CCR or Card Interface Device (CID) or Clipper Tri-Readers) obtained through the Clipper program from Metropolitan Transportation Commission/Cubic.

PART 3 - EXECUTION

3.01 EQUIPMENT DELIVERY

A. Clipper Card Readers will be stored at the VTA Guadalupe Maintenance Facility.

B. Package, load, transport, unload, and unpack Clipper Card Readers from the Guadalupe Maintenance Facility to the installation site.

C. Transport TVM printers, controllers, and bill note acceptors separately from TVM cabinets after TVM have been installed. (VTA will transport revenue modules.)

3.02 INSTALLATION

A. General:

1. Install TVMs in accordance with the Installation Plan for Ventek TVM Units, included as Attachment 1 to this Contract Specifications Section, and as indicated herein.

2. Install communications and power ducts, conduits, vaults, wires and cables, cabinets, and power supplies as required to connect the TVMs and CCRs.

B. Install the following cables for each TVM:

1. 120 VAC, 20 amp dedicated circuit

2. CAT6 cable:

   a. Install CAT6 patch cables using RJ45 connectors.

   b. The CAT6 cables must originate from the IT Edge Station LAN Switch located within the TVM housing.

   c. Install the patch cord to patch the connection from the IT Edge Station LAN Switch to each TVM controller.

3. Connect the IT Edge Station LAN Switch to the Station IT LAN Switch as specified.

C. TVM Pedestal

1. Set pedestal on anchor bolts as indicated in installation procedures. Anchor bolts must be set into the mounting pad using epoxy adhesive in 11/16 inch diameter by 4 inch deep holes drilled into the pad. Minimum cure time for the epoxy must be 24 hours from the time the epoxy is placed to install of equipment. Install anchor bolts in accordance with templates 61-110 as indicated.

2. Level pedestal using 5/8 inch hex jam nuts with USS washers on each anchor bolt. As measured along both the edge of the pedestal and across the pedestal, the pedestal must not be out of level by more than one percent.

3. After leveling, fasten pedestal in place with 5/8 inch hex nuts over USS washers. Torque nuts to 70 ft-lbs.

4. Grout the gap between the bottom of the pedestal and the mounting surface with non-shrink grout to form a water-tight seal around the pedestal

5. Power cables:

   a. Pull in 3-conductor, 12 AWG power cables from power panels to TVM pedestal.

D. Clipper Card Readers (CCRs):

1. For each CCR, install breakers for:

   a. Dedicated 120 VAC circuits and power cables to 24VDC power supplies in the communications room.

2. Install CAT6 cable and adapters as required.

3. Install VFE CCR base and pole on a concrete foundation for each VTA CCR.

E. Grounding: Ground equipment in accordance with the requirements indicated, Grounding and Bonding, and in accordance to manufacturer's requirements.

F. Follow TVM manufacturer's installation instructions, the Installation Plan Ticket Vending Machine (TVM), from Ventek International.

3.03 TESTING

A. Contractor Testing:

1. Contractor must test before install, install and retest after installation, all components furnished by VTA.

2. Wires and Cables: Test all wires and cables prior to connection to TVMs or CCRs

3. Test connection between TVM and IT IP Switch.

4. Test connection between CCR head and IT IP Switch.

5. Test network connection from IT IP Switches via the Communications Network to River Oaks data canter.

B. VTA Testing:

1. Provide support during the performance of TVM and CCRs testing, and any additional field acceptance tests to be performed by VTA, including SCADA alarms for the TVM.

2. Support must include troubleshooting and repair of power and data connections and network switch configuration.

END OF SECTION

SECTION 34 54 01

AUTOMATED FARE COLLECTION SYSTEM PROCUREMENT

PART 1 - GENERAL

1.01 SUMMARY

This Technical Specifications Section provides requirements regarding Fare Collection Equipment Related Procurement Work, including:

A. Requirements for procurement of Automated Fare Collection Equipment including Ticket Vending Machines (TVM), and all required related accessories required to complete the Automated Fare Collection System.

B. Note that VTA will provide refurbished Bill Note Acceptors (BNA 57) and PIN Pads (from VTA spares), and Clipper Card Readers (also known as CCR or Card Interface Device (CID) or Clipper Tri-Readers) obtained through the Clipper program from Metropolitan Transportation Commission/Cubic. Contractor must test and install and retest all components furnished by VTA.

C. Procure a total of five VTA TVMs:

1. Two TVMs for the Eastridge Station West Entrance at the Transit Plaza.

2. One TVM for the Eastridge Station Platform, just north of the north passenger shelter.

3. Two TVMs on the Story Station Platform at the entrance to the Station Platform, just north of the south platform staircase.

D. The work must include vendor (Ventek International Inc.) support during procurement, and vendor shall provide continued support and integration services at the stations, at VROF, and at other locations necessary to provide a completely functional and tested system of TVMs and CCRs, including all features and functionality as specified, and that exist throughout the existing VTA LRT system.

1.02 RELATED SECTIONS

A. Section 27 05 28 – Pathways for Communications Systems

B. Section 27 11 16 – Communications Cabinets, Racks, Frames and Enclosures

C. Section 27 11 19 – Communications Terminal Blocks and Patch Panels

D. Section 27 13 00 – Communications Network Cabling

E. Section 27 15 00 – Communications Low-Voltage Conductors and Cables

F. Section 27 21 00 – Communications Network Equipment

G. Section 27 26 00 – Communications Programming and Integration Services

H. Section 27 42 19 – Public Address System

I. Section 27 42 20 – Passenger Information Monitor System

J. Section 28 20 00 – Video Surveillance (CCTV)

K. Section 28 40 00 – SCADA Monitoring and Control System

L. Section 34 54 00 – Automated Fare Collection System Installation

1.03 REFERENCES

A. The latest versions of the following standards and references apply to the work included in this Section, in addition to those codes and standards common to all communications subsystems specified in section 27 05 00 "Common Work Results for Communications". If a conflict must arise between various standards, the California state code amendments must govern, or the most strict/conservative requirement must govern.

B. American National Standard Institute (ANSI):

1. ANSI C2 National Electric Safety Code (NESC)

C. California Electrical Code

D. Electronics Industries Association (EIA):

1. EIA/ECA-310-E Cabinets, Racks, Panels, and Associated Equipment

E. National Electrical Manufacturers Association (NEMA):

1. NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum).

F. State of California Code of Regulations (Title 24)

G. Underwriters Laboratories, Inc. (UL)

1.04 SUBMITTALS

A. The Contractor must provide a minimum of one (1) electronic version (in both Microsoft Work and Adobe PDF format) and two (2) hard copies of each document deliverable, and more copies as may be required elsewhere in these specifications.

B. Product Data: Provide technical data, including list of equipment and material, manufacturer's descriptive and technical literature, and catalog cuts.

C. 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 with product data attesting that the items furnished under this Technical Specifications Section conform to the specified requirements.

D. The Contractor must provide equipment documentation and operations and maintenance training for all components, including those that are new to VTA.

E. Contractor must prepare documentation of the Provend IV TVM configuration and major components identifying differences between the Provend IV TVM and the VTA production TVMs for VTA review and approval.

F. List of required Contractor supplied Deliverables and VTA required Schedule Dates:

Task	End Result/Deliverable	Acceptance Criteria	Schedule/Milestone
1	TVM Documentation	Subject to VTA Approval	NTP* + 14 days
2	Factory Testing Plan/Procedures	Subject to VTA Approval	NTP + 30 days
3	Project Schedule	Subject to VTA Approval	NTP + 14 days
4	Production TVMs	NA	NTP + 150 days
5	Factory Test Reports on Production TVMs	Subject to VTA Approval	Test Completion + 7 days
6	Delivery of TVMs	Delivery Inspection	After Test Approval, when project site is ready for installation.
7	Final equipment documentation	Subject to VTA Approval	With Delivery of TVMs
8	Training material	Subject to VTA Approval	With Delivery of TVMs
9	Training sessions	NA	Within 5 days of TVM installed and field tested

*NTP = Notice to Proceed

1.05 ABBREVIATIONS

A. General:

1. CID Card Interface Device
2. CCR Clipper Card Readers
3. TVM Ticket Vending Machine

1.06 MEASUREMENT AND PAYMENT

A. Measurement: Ticket Vending Machine procurement shall be measured by individual unit (each).

B. Payment: The contract price paid per individual unit (each) for Ticket Vending Machine procurement and Card Interface Device (CID, CCR) procurement shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in supplying the Ticket Vending Machines and Card Interface Devices (CID, CCR) delivered to the project site as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.01 INTRODUCTION

A. This contract must involve the production, factory testing, and delivery of Ventek Provend IV ticket vending machines (TVMs) similar and compatible to those currently serving VTA customers on the existing light rail lines. The TVMs must vend transit fares, provide customer information, and add value and products to Clipper cards (CCR). Payment for VTA fares and for Clipper Card (CCR) products must be made in the form of tokens, cash or credit/debit cards.

B. VTA will provide the Clipper Tri-Reader from MTC/Cubic which are required for compatibility with the Clipper cards and interface software developed by Ventek. Contractor cannot acquire these modules directly.

2.02 TICKET VENDING MACHINE

A. The Contractor must provide the Ventek model number Provend IV TVMs, with custom modifications as described below.

B. The Contractor must make minor modifications to the Ventek model number Provend IV TVMs, which VTA is currently using. These modifications are necessary for the substitution of certain components that are no longer manufactured and in current production. In addition, the Contractor must provide equipment documentation and operations and maintenance training for the components that are new to VTA.

C. Contractor must prepare documentation of the Provend IV TVM configuration and major components identifying differences between the Provend IV TVM and the VTA production TVMs for VTA review and approval.

D. TVM Fabrication and Assembly: Contractor must fabricate and assemble 5 (five) TVMs in accordance with the approved TVM documentation and following established quality control standards approved by VTA.

E. Inclusion of Owner furnished components: VTA shall provide refurbished Bill Note Acceptors (BNA 57), and PIN pads from VTA's spare parts (PIN pads are no longer manufactured by MGR). Contractor to test, install, and retest after installation, all components furnished by VTA.

F. The Contractor must supply and install at the manufacturing site, a hardened 750 VA Uninterruptible Power Supply (UPS), one for each TVM, compatible with the TVM, suitable for installation within the TVM and in accordance with required environmental conditions.

G. The TVM shall integrate the Information Technology (IT) Edge Station LAN Switch, as part of the TVM, during the fabrication/manufacturing process. The Contractor shall also supply the work area outlets shown in the communications drawings, including interconnecting cabling from TVM equipment to the IT Edge Station LAN Switch.

H. The TVM must provide the following components and meet the following requirements, all components must be in current production and commercially available, and the latest versions available:

1. The TVM shall be the Ventek IV TVM as manufactured by Ventek International, of Petaluma, California, no substitution shall be allowed, since the TVM must be compatible with the existing VTA TVMs and OCC software and systems, and must include the modifications described in this section.

2. Cabinet: 11 gauge stainless steel with base.

3. System Controller: SBC assembly (02-505-VTA-C2) with Windows 7 Embedded Operating System (OS), or newest version of OS available at time TVMs are procured as may be selected by VTA, and Compact Flash Card (12-507-8G).
4. Door I/O Module: Ventek Part 02-204.
5. Security Module: Provend IV.
6. Printers: Boca Thermal Printers.
7. Card Reader: Magtek, Ventek Part 13-501-VTA.
8. Display Screen: 15" color LCD display.
9. Debit PIN Pad: Provided by VTA (MGR-Ventek Part 31-084C)
10. Uninterruptible Power Supply (UPS): 750 VA.
11. Bill Acceptor Interface Module: Ventek Part 02-212.
12. Coin Acceptor Module: Provend IV.
13. Access Pad: 12 key
14. Bill Note Acceptor: Provided by VTA (BNA57, refurbished).
15. Bill Vault: Not required.
16. Coin Hoppers: Not required.
17. Coin Vault: Not required.
18. Compatible with Clipper Card Reader (Cubic Tri-Reader)

2.03 ADD VALUE MACHINE

A. The Contractor must provide Add Value Machine functionality included and integrated with the TVM, and must provide functionality to add value and products to Clipper cards (CCR).

2.04 TVM/CCR ETHERNET SWITCH

A. The TVM/CCR Ethernet Switch must be the Information Technology (IT) Edge Station LAN Switch, excluding the switch enclosure, as specified in section 2.08 of Technical Specifications section 27 21 00.

B. The TVM/CCR Ethernet Switch shall be mounted internally to the TVM, and shall be DIN rail mounted as specified.

PART 3 - EXECUTION

3.01 VTA FURNISHED EQUIPMENT

A. VTA Furnished Equipment (VFE) is stored at the VTA Guadalupe Maintenance Facility, and is available upon 24 hours notice from the Contractor, for the Contractor to pick up.

B. Contractor must package, load, transport, unload, and unpack VFE from the Guadalupe Maintenance Facility to the manufacturing site.

C. Transport TVM printers, controllers, and bill note acceptors separately from TVM cabinets after TVM have been installed. (VTA will transport revenue modules.)

3.02 EQUIPMENT MANUFACTURE

A. Contractor shall integrate VFE with contractor supplied materials and manufacturing processes, and complete integrated and functional TVMs.

B. Contractor shall store the completed TVMs at the manufacturing site at no cost to VTA, until the EBRC project construction has advanced to the point where the TVMs must be installed.

3.03 FACTORY ACCEPTANCE TESTING

A. Contractor to perform factory testing of assembled TVMs to demonstrate TVM, Add Value Machine (AVM), UPS/battery backup functionality, and Information Technology (IT) Edge Station LAN Switch functionality with integrated VFE, in accordance with the VTA approved factory testing plan and procedures.

B. VTA will inspect TVM fabrication and monitor TVM factory testing, Contractor shall coordinate and schedule this work to coincide with VTA approved fabrications/manufacturing schedule milestones.

C. VTA must approve completion of fabrication/manufacturing, and FAT testing report results, prior to the Contractor shipping the completed TVMs to the EBRC project site.

3.04 EQUIPMENT DELIVERY

A. Package, load, transport, unload, and unpack the TVMs to the installation site. Inspect for any signs of damage during shipping and advise VTA immediately should damage be present.

B. Transport TVM printers, controllers, and bill note acceptors separately from TVM cabinets after TVM have been installed. VTA will transport revenue modules.

3.05 EQUIPMENT TRAINING

A. Contractor shall provide VTA staff training on software, configurations, and components unique to new TVMs. (It is expected that, to cover this material, Contractor would provide two (2) two-hour training sessions for VTA staff already experienced in operating and maintaining the TVMs.)

END OF SECTION

SECTION 34 71 13

VEHICLE BARRIERS

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for placing vehicle barriers of various types.

1.02 RELATED SECTIONS

A. Section 6, Special Conditions

B. Section 7, General Conditions

1.03 REFERENCED STANDARDS

A. State of California, Department of Transportation (Caltrans), Standard Specifications:

1. Section 83, Railings and Barriers

1.04 SUBMITTALS

A. Refer to Section 6.6, Contract Data Requirements, and Section 7.43, Submittal of Shop Drawings, Product Data and Samples for requirements.

B. Product Data: Submit product data for the following:

1. Concrete Mix Design
2. Reinforcement
3. In-Line Terminal System End Treatment

1.05 MEASUREMENT AND PAYMENT

A. Measurement:

1. CONCRETE BARRIER TYPE 60M shall be measured by the Linear Foot.
2. IN-LINE TERMINAL SYSTEM END TREATMENT shall be measured by the Unit.

B. Payment:

1. The contract price paid per linear foot for CONCRETE BARRIER TYPE 60M shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in placing concrete barrier, complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

2. The contract price paid per unit for IN-LINE TERMINAL SYSTEM END TREATMENT shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in gates encasement in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 CONCRETE BARRIER

A. Concrete barrier material shall conform to Caltrans Standard Specification Section 83, Railings and Barriers.

2.02 IN-LINE TERMINAL SYSTEM END TREATMENT

A. In-line terminal system end treatment material shall conform to Caltrans Standard Specification Section 83, Railings and Barriers.

B. The Contractor shall provide VTA with a Certificate of Compliance from manufacturer in conform with Section 7.49, Certificates of Compliance and Testing. The Certificate of Compliance shall certify that the end treatment conforms to the contract plans and specifications, conforms to the prequalified design and material requirements, and was manufactured in conformance with the approved quality control program.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install concrete barriers in accordance with Caltrans Standard Specifications 83, Railings and Barriers

B. Install in-line terminal system end treatment per manufacturer's instructions.

END OF SECTION 34 71 13

SECTION 34 71 19.16

FLEXIBLE VEHICLE DELINEATORS

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes specifications for furnishing and installing surface applied Flexible Bollard System and Reflective Tapes at Platforms as indicated in the Contract Drawings.

1.02 RELATED SECTIONS

A. Section 03 30 00 – Cast-in-Place Concrete

B. Section 03 53 00 – Concrete Topping

C. Section 32 17 26 – Tactile Warning Surfacing

1.03 REFERENCED STANDARDS

A. ASTM International

1. ASTM G155 — Standard Practice for Operating Xenon-Arc Light Apparatus for Exposure of Nonmetallic Materials

B. Underwriters Laboratory (UL):

1. UL 94 — Standard for Safety of Flammability of Plastic Materials for Parts in Devices and Appliances testing

1.04 SUBMITTALS

A. General

1. Submittals for Flexible Bollard System must be made in accordance with the provisions in these technical specifications.
2. Contractor must submit shop drawings, product data, and samples:
    a. Shop Drawings: TBD.
    b. Product Data: Submit manufacturer’s literature describing products, installation procedures, and routine manintenance.
    c. Samples: Submit three (3) samples of full size Flexible Vehicle Delineator System including tape.

1.05 MEASUREMENT AND PAYMENT

A. Measurement: Flexible Vehicle delineators must be measured by each item.

B. Payment: The contract price paid per each item for Flexible Vehicle Delineators must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all

Work involved in constructing Flexible Vehicle Delineators complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 MANUFACTURER

A. Basis of Design: Sentinel BCB – Between Car Barriers as manufactured by Impact Recovery System Inc, or VTA approved equal.
Basis of Design: Reflective Tape as manufactured by 3M or VTA approved equal.

1. Proprietary Products: Use of manufacturer's proprietary product names to designate materials and finishes is not intended to imply that products named are required to be used to the exclusion of equivalent products of other manufacturers. Equivalent products must meet or exceed the requirements of these specifications. Furnish manufacturer's material data that indicates compliance with the requirements of Part 1 of this Section.
2. Manufacturer: Impact Recovery Systems, Inc, 4955 Stout Dr., San Antonio, TX 78219. Phone: (210) 736-4477. Email: impactrecovery.com.
3. 3M , 3M Center, St. Paul, MN 55144-1000; Phone (888)-364-3577; Website: 3m.com

2.02 MATERIALS

A. Base Rail:

1. Base rail to be comprised of a proprietary blend of materials that satisfy the mechanical, cosmetic and other performance requirements of the nation's metropolitan transit authorities.
2. Base rail shall be independently tested and certified to meet fire retardant material characteristics resulting in a UL 94 V-0 fire rating.
3. Base rail to contain UV inhibitors which will achieve a Delta E measurement of 2 and a minimum gloss retention level of 60 percent after four (4) years of weathering. Accelerated weathering testing shall be conducted in accordance with ASTM G155 2500 kl.
4. Base rail to contain materials which provide chemical resistance and resistance to damage from ozone and hydrocarbons.
   a. Color: Safety Yellow
   b. Post Heights: 42"
   c. Rail Width: 8'-0"
   d. Rail Height: .94
   e. Rail Length: 36"
   f. Rail Sockets: 4
   g. End caps: 4-inches, 12-inches (1 socket)
   h. Fire Retardance: UL-VO

B. Bollard: Upright tubes shall be 2.42" in diameter, and shall be available in a variety of heights to accommodate the requirements of each application.

1. Upright to contain compression spring assembly, stainless steel wire rope and two-piece knuckle which has been independently tested and certified to comply with a UL 94 V-0 level fire retardancy.

C. End caps: Must not exceed 1" in height

D. Reflective Tape:

1. 3-inch
2. Color: White and Safety Yellow

E. Installation hardware: All hardware to attach uprights to base rail shall be included. All supplied hardware must be stainless steel, tamper-resistant, and as stated in the Contract Documents.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Verification of conditions: Examine areas to receive Flexible Bollard System; verify for correct location.

B. Notify Engineer in writing of unacceptable substrate or improper location for anchors.

C. Beginning work indicates acceptance of substrate.

3.02 INSTALLATION

A. Install anchors in locations indicated in accordance with reviewed shop drawings. Square, plumb, and level units; install related trim pieces.

B. Install as indicated in Drawings and as recommended by manufacturers' installation instructions.

3.03 CLEANING

A. Clean exposed surfaces not more than 48 hours prior to Date of Substantial Completion in accord with manufacturer's instructions.

END OF SECTION 34 71 19.16

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