IMPORTANT:

The Engineering Standards (Design Criteria, Standard Drawings and Standard Specifications) are currently being updated.

If access is needed to the 2011 Standards, please email Caltrain Engineering at engineeringstandards@samtrans.com and include why the Standards are required and your contact information.
These Caltrain Standard drawings supersede Standards dated April 15, 2007.

Check for any updates online as well as send any suggestions or changes through www.Caltrain.com.

Caltrain Standards consist of:

1. Design Criteria
2. Standard Drawings
3. Standard Specifications
4. Standards for Design and Maintenance of Structures
5. Engineering Standards for Excavation Support Systems
6. CADD Manual

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### Document Revision History

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Engineering Manager

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SECTION 02100
DEMOLITION

PART 1 – GENERAL

1.01 DESCRIPTION
A. Section includes regulatory and general requirements for demolition.

1.02 REFERENCE STANDARDS
A. State of California, Department of Transportation Standard Specifications (Caltrans):
   Section 15 Existing Highway Facilities

1.03 RESTRICTIONS
A. Do not sell or burn removed materials on-site.
B. Do not use explosives.

1.04 SUBMITTALS
A. Demolition Plan: Submit demolition plan for approval: Indicate methods to be employed, sequence, equipment, procedures, disposal sites, and proposed haul routes. Indicate safety measures in accordance with applicable codes, including signs, barriers and temporary walkways.

1.05 DELIVERABLES
A. Submit permits and notices authorizing demolition, as required.
B. Submit copies of manifests showing delivery of disposed materials in accordance with permit conditions within 24 hours from time of delivery.

1.06 REGULATORY REQUIREMENTS
A. Perform work of this Section in accordance with applicable laws, ordinances, and requirements of the agencies having jurisdiction.
B. Unless otherwise specified, perform work in accordance with the following:
1.07 PROJECT CONDITIONS
A. Provide and maintain all required temporary construction and facilities for the support and protection of the existing structures to remain.
B. Protection and Interruption of Utilities: Refer to Specification Section 01047, Utilities and Systems Coordination, for location, notification, and protection requirements in regard to existing utilities and systems facilities.
C. Refer to Specification Section 01560, Temporary Controls, for requirements for dust control. Provide continuous dust abatement as required.

PART 2 – PRODUCTS

2.01 MATERIALS
A. Provide temporary or permanent materials as required for the proper execution of the Work of this Section.

2.02 DUNNAGE
A. Provide pallets, sills and other materials for packaging and stacking salvaged items which are clean, free of decay or other defects, and sufficiently sturdy for the service intended.

2.03 MARKING PAINT
A. Marking Paint: Spray marking paint or paint marker, suitable for duration of service required.

PART 3 – EXECUTION

3.01 PREPARATION
A. Inspect existing conditions and note dimensions, clearances, access, utilities, shoring and protection required.
B. Have in place, before demolition begins, required protection measures, protective and regulatory devices, and personnel. Protective measures include barricades, warning and temporary routing signs, lights and similar devices.
C. Where an abutting structure or a part of a structure is to be left in place, make clean, smooth, vertical cuts with a saw or other approved cutting device to lines indicated. If not indicated or otherwise required, demolish structure to a minimum of 18 inches below subgrade.
D. The Contractor may salvage materials from demolition for use in temporary facilities but shall not use the salvaged materials in the Work unless approved in writing by the Engineer for each specific case, or unless specifically called for in the Contract Documents.
E. Obtain utility shut off to safely execute the work.
F. Verify that structures to be removed are cleared of utilities.
G. Provide temporary construction for the maintenance, support and protection of existing adjacent structures and facilities that are to remain.

3.02 DEMOLITION

A. General:

1. Perform work of this Section in conformance with Caltrans Standard Specifications Section 15, Existing Highway Facilities.

2. Do not place demolished material or demolition equipment where it will create excessive loads on any structure.

3. If unforeseen obstructions are encountered, obtain instructions from the Engineer before proceeding with the work.

4. Promptly repair, restore or replace damage, disturbance, or impairment of existing facilities to remain.

5. Repair or replace items to remain or to be salvaged which are damaged during demolition to the satisfaction of the Engineer or private property owner(s).

6. Refer to Specification Section 20200, Track Removal and Salvage, for related requirements in regard to track demolition, as applicable.

B. Salvage:

1. Salvage existing facilities as shown on the Contract Drawings and transport to location designated by the Engineer within 30 miles of the work site.

2. Take necessary precautions to disconnect, remove, protect, transport, and store salvaged items in a manner that will prevent damage.

C. Removal:

1. Remove existing facilities as shown on the Contract Drawings.

2. Wet down concrete materials during demolition to prevent spread of dust and dirt. Do not use water in a manner that would cause damage or contaminate runoff. Refer to Special Conditions Section 01560, Temporary Control, in regard to control or erosion and pollution prevention.

3. Fill below grade areas and voids resulting from removal of below-grade structures and utilities, and compact to indicated grade in accordance with Specification Section 02300, Earthwork.

4. Remove abandoned conduit, wiring and piping to the source of supply, or Limit of Work.

5. Saw cut concrete or asphalt pavement to 3 inches depth, with saw designed for cutting pavements, prior to pavement removal. Cuts shall be straight and free of ragged edges.

6. Remove traffic stripes, pavement markings, and pavement markers in
conformance to Caltrans Standard Specifications, Section 15-2.02B and 15-2.02C.

D. Disposal: Refer to General Provisions 7.16, Disposal of Material Outside of the Work Site.

1. Do not store or stockpile on Caltrain property material designated for disposal, except as indicated in the Contract Documents.

2. Removed items that are not scheduled or shown on the Contract Drawings to be salvaged or re-used shall become the property of the Contractor and shall be disposed of outside of the work site.

3. Keep the project area clear of refuse and rubbish, and maintain the area in a neat condition.

E. Relocation:

1. Remove and install existing facilities in a new location.

F. Reconstruction:

1. Remove and disassemble existing facilities as shown on the Contract Drawings and construct again at the existing location or a new location.

2. Provide new parts or alteration to the existing facility as required.

3. Protect items removed for reconstruction from damage during removal, disassembly and final construction. Repair or replace any damaged facilities.

G. Modification:

1. Modify existing facilities as indicated on the Contract Drawings.

3.03 PRESERVATION OF REFERENCE MARKERS

A. Refer to Specification Section 01050, Field Engineering. Make arrangements with the Engineer to replace any survey markers and monuments missing or damaged during construction.

B. Store removed markers and monuments during demolition work.

END OF SECTION
SECTION 02110
SITE CLEARING

PART 1 – GENERAL

1.01 DESCRIPTION
A. Section includes specifications for clearing and grubbing. Perform site clearing in advance of grading and other construction operations.

1.02 REFERENCE STANDARDS
A. State of California, Department of Transportation, Standard Specifications (Caltrans)
   1. Section 16 Clearing and Grubbing

1.03 SUBMITTALS
A. Site Clearing Plan: Indicate location and limits of clearing and grubbing, methods, equipment, procedures, safety and protection measures, and disposal sites.

1.04 DELIVERABLES
A. Submit copies of manifests showing delivery of disposed materials in accordance with permit conditions within 24 hours from time of delivery.

PART 2 - PRODUCTS

2.01 MATERIALS
A. Provide temporary or permanent materials as required for the proper execution of the work of this Section.

PART 3 - EXECUTION

3.01 GENERAL
A. Perform site clearing in accordance with Caltrans Standard Specifications Section 16.
B. Maintain a clear site until covered by new work or until completion of the Work.
C. Clear, grub, prune, remove, and dispose of materials, including bushes, brush, trees, stumps, fallen timber, logs, roots, signs, rubbish, refuse, trash and debris as shown on the Contract Drawings, specified herein, and as required to perform the work of the Contract.
D. Refer to Section 01560, Temporary Controls, for requirements for storm water pollution prevention and dust control.
E. Provide barricades, coverings, or other types of protection necessary to prevent damage to existing improvements indicated to remain in place. Protect improvements on adjacent properties as well as those on PCJPB property. Restore existing improvements damaged by the work to original condition to the satisfaction...
of the Engineer.

F. Refer to Section 02510, Utility Grade Adjustments, for specifications for raising and resetting existing frames, covers, and lids to meet new finish grade elevations.

G. Upon completion of site clearing work, Caltrain property and adjacent areas shall be neat, clean and in condition to receive subsequent work.

H. Carefully remove items to be salvaged, and store where required by the Engineer or where indicated in the Contract Documents.

3.02 LIMITS OF SITE CLEARING

A. Perform site clearing sufficient to perform the construction work shown in these Contract Documents. In addition, perform site clearing as follows:

1. Perform site clearing for track construction for a distance of 15 feet measured perpendicular from the centerline of track outward toward the right-of-way, or from the centerline to the right-of-way, whichever is less.

2. Perform site clearing to three (3) feet beyond the toe of new embankments.

3. Perform site clearing at grade crossings to a distance of not less than 100 feet in each direction of approach to grade crossings, within the entire width of the right-of-way, unless otherwise indicated on the Contract Drawings.

3.03 CLEARING

A. Cut, remove and dispose of all timber, brush, fallen timber, stumps and rubbish except trees or other vegetation that is designated for preservation on the Contract Drawings. Retain and protect from damage any trees and shrubs that are outside the limits of the required clearing.

B. Completely remove trees, stumps, shrubbery, and brush in areas where embankment will be placed.

C. Remove stumps and roots completely in excavation areas and under embankments where the original ground level is within 3.5 feet of subgrade or slope of embankments. In embankment areas, where the original ground level is more than 3.5 feet below the sub grade or slope of embankment, cut off trees, stumps, and brush to within 6 inches of the ground.

D. Do not start earthwork operations in areas where clearing and grubbing are not complete, except that stumps and large roots may be removed concurrently with excavation.

3.04 GRUBBING AND STRIPPING

A. Grubbing: Excavate, remove and dispose of all roots, stumps, and other vegetation to a minimum depth of 30 inches. Measured depth shall be from existing ground surface or new finished grade, whichever is lower. Leave ground surface in a condition suitable for stripping of topsoil.

B. Stripping: Excavate and remove topsoil (including any remaining vegetation) which is not classified as suitable fill material down to suitable fill material, except in plant bed areas. Salvage topsoil if required in the Contract Documents.
3.05 EXISTING TREES AND VEGETATION

A. Protect existing trees indicated to remain in place against cutting, breaking or skinning of roots, skinning and bruising of bark, smothering of trees by stockpiling building materials or excavated materials within drip line, excess foot or vehicular traffic, or parking of vehicles within drip line. Provide temporary fences, barricades or guards at dripline to protect trees. Trees within limits of contract work shall be watered as required by the Engineer.

B. When it is necessary to cut tree roots to provide room for new construction, cleanly saw tree roots over 1-1/2 inches diameter. Cover exposed roots with wet burlap to prevent roots from drying out.

C. Where trees or shrubbery designated to remain or those in areas outside the area indicated to be cleared and grubbed are damaged in the course of the Work, repair damage to or replace damaged existing trees and shrubbery to the Engineer’s satisfaction.

3.06 EXISTING STRUCTURES AND PROPERTY

A. Obtain permission from the Engineer prior to removing signs, posts, catch basin frames and grates, and manhole frames and covers not indicated on the Contract Drawings for removal.

B. Protect existing structures and facilities not to be removed.

C. Store salvaged items in an orderly manner as directed by the Engineer.

D. Protect existing survey monuments. Refer to Section 01050, Field Engineering, for procedures for replacement of disturbed or damaged bench marks or monuments.

3.07 DISPOSAL

A. Disposal: Refer to General Provisions 7.16, Disposal of Material Outside of the Work Site.

1. Do not store or stockpile on Caltrain property material designated for disposal, except as indicated in the Contract Documents.

2. Debris and material that is not scheduled or shown on the Contract Drawings to be salvaged or re-used, shall become the property of the Contractor and shall be disposed of outside of the work site.

B. Keep the project area clear of refuse and rubbish, and maintain the area in a neat condition.

END OF SECTION
SECTION 02200
SUPPORT OF EXCAVATION

PART 1 – GENERAL

1.01 DESCRIPTION

A. Section including specifications for design and installation of excavation support.

B. Section also includes specifications for excavation support systems the design of which is indicated on the Contract Drawings, as applicable.

1.02 GENERAL

A. Refer to General Conditions 7.15, Trench Excavation Safety Plan, for basic requirements related to this Section.

1.03 REFERENCE STANDARDS

A. American Railway Engineering and Maintenance-of-Way Association (AREMA):


B. ASTM (ASTM International):

1. A36 Specification for Carbon Structural Steel

2. A53 Specification for Pipe, Steel, Black and Hot Dipped, Zinc-Coated, Welded and Seamless

3. A252 Specification for Welded and Seamless Steel Pipe Piles

4. A328 Specification for Structural Steel for Steel Sheet Piling

5. A500 Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shape

6. A572 Specification for High-Strength Low-Alloy columbium-Vanadium Structural Steel

7. A992 Specification for Structural Shapes

C. American Welding Society (AWS):

1. D1.1 Structural Welding Code

D. American Wood Preservers Association (AWPA):

1. U1 User Specification for Treated Wood
Caltrain Standard Specifications

E. California Code of Regulations (CCR):
   1. Title 8, Chapter 4, Subchapter 4, Construction Safety Orders

F. Caltrain Engineering Standards for Excavation Support Systems

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

1.04 DEFINITIONS

A. Railroad Zone of Influence: Refer to Caltrain Engineering Standards for Excavation Support Systems.

1.05 DESIGN CRITERIA

A. Temporary excavation support (shoring) shall conform to the requirements in the Caltrans Trenching and Shoring Manual and Caltrain Engineering Standards for Excavation Support Systems.

B. Excavations adjacent to active tracks: Excavations below the Zone of Influence Line indicated in the Contract Drawings shall be supported in accordance with Caltrain Engineering Standards for Excavation Support Systems. The Contractor may request a waiver of railroad loading requirements when excavations are less than 4 feet deep, less than 4 feet square in area and are not closer than 10 feet from the center line at the track.

C. Where physical conditions of design require the placing of excavation support closer than specified herein, the design shall be submitted to the Engineer for review and approval of a waiver.

D. When support of track or tracks is necessary during construction (that is shoring adjacent to active tracks), interlocking steel sheet piling adequately braced and designed to carry Cooper E-80 live load is required. Soldier piles and lagging will be permitted for supporting adjacent track or tracks only when required penetration of steel sheet piling cannot be obtained or when, if approved by the Engineer, steel sheet piling would be impractical to place.

   1. Do not use soldier piles and lagging for any shoring systems within the Railroad Zone of Influence.

E. The excavation support shall allow safe and expeditious construction of the permanent structure and shall be designed to carry the loads imposed upon it, including earth pressures, vehicular traffic loading, railroad loading, utility loads, loads from adjacent structures, ground water pressure, equipment and construction loads, without movement or settlement of adjacent structures, utilities, or tracks.

F. Design splices in structural steel members to develop 100 percent of the strength of the member.
G. Cover excavations. Protect excavations by handrails, barricades, and warning lights.

1.06 SUBMITTALS

A. Excavation Shoring Systems: Submit the following showing the proposed methods of construction, design, and details:

1. Detailed working drawings for temporary shoring including the following: Plans, elevations, sections and details that clearly describe the systems to be installed to include the methods and procedures of installation to be followed and a description of each material to be employed. Dimensions and spacing of members shall be clearly noted. Include existing utility locations and temporary supports for utilities.

2. Design computations demonstrating that the required design parameters have been met.

3. Product data for materials and equipment.

B. For Owner-Designed Excavation Shoring Systems, as Applicable: Submit the following:

1. Shop drawings showing excavation support elements, including layout of piles and bracing elements. Identify and show location of existing utilities in both plan and elevation.

2. Include details showing how the excavation support system will be installed around utilities.

3. Design of temporary supports for utilities to be maintained across the excavations.

C. Submit the following as applicable to specific support systems:

1. Construction and installation procedures, excavation sequence, interface details, protection measures for existing structures and facilities, and contingency plans for excessive movement of existing walls and other facilities.

2. Concrete mix designs as specified in Section 03300, Cast-in-Place Concrete.

3. Soil-cement design mixes, including test data demonstrating that the proposed mixes will meet required strength.

4. Quality control/quality assurance plan for soil-mix wall construction. Coordinate with Section 01400, Quality Control and Assurance, suitable for demonstrating that the soil-mix walls have been installed to the required depths and dimensions and will have the required strength, continuity, and permeability at the time of excavation. Include the means of continuously monitoring the slurry injection process during soil mixing, soil-cement sampling methods and frequency, and soil-cement testing methods and frequency.
D. Submit instrumentation and monitoring plan that includes the following information:

1. Drawings showing planned locations and identification numbers for each settlement point, railroad settlement point, and monitoring well.

2. Proposed schedule for installing and for monitoring settlement points, railroad settlement points, inclinometers, and monitoring wells.

3. Descriptions and details for methods and materials to be used in the installation of settlement points, railroad settlement points, inclinometers, and monitoring wells.

4. Manufacturer’s literature including product descriptions, and operation and maintenance procedures for instruments.

5. Details for abandoning instruments at the completion of the Work.

E. Submit as-built drawings of instrumentation installation within 5 days of completion of instrument installation.

1.07 DELIVERABLES

A. Submit written confirmation signed by the Civil Engineer of the temporary shoring systems that the shoring systems have been constructed in accordance with the approved submittals.

B. Submit the following as applicable to specific support systems:

1. Deliverables specified under Section 05200, Structural Steel.

2. Soil-cement testing results within 3 days of tests being performed.

3. Instrument readings within 3 days of the readings being taken.

1.08 QUALITY ASSURANCE

A. Temporary Shoring:

1. Temporary shoring designs including working drawings and calculations shall be prepared, sealed, and signed by a Civil Engineer hired by the Contractor who is currently registered in the State of California, has previous experience in the design of temporary shoring systems, and is qualified as required in the Caltrain Engineering Standards for Excavation Support Systems.

3. Contractor’s Civil Engineer for the shoring design shall inspect the as-built shoring system to verify that the system is constructed in accordance with the approved shoring plans. The number of site visits and the stage or stages of construction at which they shall be performed shall be as required by the Engineer as a condition of approval of the shoring system.

4. Maintain sheeting, bracing and other temporary protective work in place and functioning until temporary protective work is no longer necessary, as determined by the Contractor’s Civil Engineer.
B. Track Monitoring:

1. Railroad tracks shall be monitored in accordance with the requirements outlined in Caltrain Engineering Standards for Excavation Support Systems.

2. Surveying for monitoring settlement points shall be performed by a Land Surveyor hired by the Contractor licensed who is currently registered in the State of California with previous experience surveying for the detection of structural or ground surface movements.

C. Comply with the following regulatory requirements:

1. CCR, Title 8, Chapter 4, Subchapter 4, Construction Safety Orders.

1.09 CONTRACTOR ALTERNATIVES

A. Where excavation support systems and details are shown on the Contract Drawings, the Contractor may propose alternate systems and details provided such systems meet the design requirements and criteria specified herein and shown on the Contract Drawings and the limitations on shoring types specified herein.

B. Alternate excavation support systems and details shall be submitted for the Engineer’s approval as specified herein for Contractor-designed excavation shoring systems.

C. Should the Contractor choose to modify the shoring system, the Contractor does so at the Contractor’s own risk and no claims for additional time or compensation will be allowed as a result of any delays or difficulties suffered.

PART 2 – PRODUCTS

2.01 TEMPORARY SHORING MATERIALS

A. Materials for temporary shoring systems may be new or used, provided they are sound and free from any strength-impairing defects.

B. Materials shall conform to the following specifications as shown on the approved submittals for Contractor-designed systems or as indicated on the Contract Drawings:

1. Structural, Plate, and Tube Steel: ASTM A36, A500, A572, or A992

2. Steel Sheet Piling: ASTM A328 or A572

3. Steel Pipe: ASTM A53 or A252

4. Concrete: As specified in Section 03300, Cast-in-Place Concrete, and shown on the Contract Drawings or in the approved submittals. Lean concrete strength shall be so proportioned that the concrete retains its shape during excavation operations.
5. Timber Shoring Elements: Douglas Fir, No. 2, or better. Timber to remain permanently in place shall be pressure-treated with preservative material in accordance with AWPA U1, User Category UC4B or UC4C.

2.02 INSTRUMENTATION AND MONITORING MATERIALS

A. Settlement Points: For paved areas: An inscribed marking of approved surveyor’s nail driven flush with the pavement surface. For unpaved areas, two (2) by two (2) inch timber stake (hub) driven flush with the ground. Each settlement point shall have an identification tag or marking.

B. Inclinometer shall consist of the following:

1. Inclinometer Casing: A special purpose grooved casing used in inclinometer installations. Casing manufactured by Slope Indicator Company, Geokon, Inc., or Engineer approved equal, including accessories necessary for installation as recommended by the manufacturer. Provide locking cap with padlock for each installed casing.

2. Inclinometer Probe: Digitilt Inclinometer Probe manufactured by Slope Indicator Company, Model 6000 Inclinometer Probe manufactured by Geokon, Inc., Engineer approved equal, including cable, pulley assembly, case and any other necessary accessories.

3. Readout Unit: Digitilt DataMate manufactured by Slope Indicator Company, Model GK-603 Inclinometer Readout manufactured by Geokon, Inc., or Engineer approved equal.

4. Software: Computer software required to reduce, to analyze, and to plot inclinometer data.

5. All inclinometer materials and equipment shall be compatible with all other inclinometer materials and equipment.

C. Monitoring Wells: Provide monitoring well materials in conformance with Contractor’s approved instrumentation and monitoring plan. Provide an instrument suitable for the purpose determining the groundwater elevation in the monitoring well.

PART 3 - EXECUTION

3.01 PREPARATION

A. Implement Instrumentation and Monitoring Program including establishing railroad settlement points by marking locations on the track using means acceptable to the ORR.

B. Prior to placing and driving steel piles or sheeting, hand dig exploratory trenches in areas where railroad underground installations are known to exist. Backfill these trenches immediately after the exploratory work is finished. Perform this work in the presence of the Engineer.

C. Coordinate support of excavation with dewatering specified in Section 02210, Dewatering, as applicable.
3.02 TEMPORARY EXCAVATION SUPPORT SYSTEMS

A. Fill cavities adjacent to the excavation support system created by driving of sheet or soldier piling with sand.

B. Unless otherwise noted or directed, all components of the support system shall be left in place, cut off at the top and the remaining portion removed as the backfill is being placed.

C. Immediately restore and tamp any ballast disturbed during construction of excavation support systems.

D. Remove any bracing tieback anchors or other support devices that are exposed.

E. Immediately fill all voids created by the excavation support members with lean concrete or sand.

F. Perform final backfilling of excavations in accordance with Section 02300, Earthwork.

G. Perform welding in accordance with the provisions of AWS D1.1.

H. Splices in structural steel members shall develop 100 percent of the strength of the member.

I. Maintain sheeting, bracing and other temporary protective work in place and functioning until temporary protective work is no longer necessary. Refer to quality assurance requirements specified herein.

J. If, at any time, existing or new construction, tracks, utilities, or similar facilities appear to be endangered, support such facilities, subject to approval of the Engineer. Provide additional bracing or shoring if considered necessary by the Engineer to safeguard against and prevent movement or settlement.

K. During construction, cut off sheet piling at the elevation of the top of adjacent tie. After construction and backfilling has been completed, remove sheet piling completely unless otherwise required by the Engineer or indicated in the Contract Documents.

L. Protect track ballast against contamination. Replace contaminated ballast.

M. Prevent settlement points from being damaged during construction.

END OF SECTION
SECTION 02210
DEWATERING

PART 1 - GENERAL

1.01 DESCRIPTION
A. Section includes specifications for temporary dewatering systems.

1.02 SYSTEM DESCRIPTION
A. Remove water which accumulates in excavations during the progress of work so that all work can be done in the dry, unless otherwise approved by the Engineer. Keep excavated areas free from water while underground utilities or structures are constructed, while concrete is setting and until backfill or elements of the structure have been placed to a sufficient height to anchor the work against possible leakage or buoyant uplift forces. A height to anchor the work against buoyant uplift forces shall be considered sufficient when the dead load weight of the backfill or elements of the structure exceeds the uplift forces by a minimum factor-of-safety of 1.5.

B. In addition to the other requirements specified herein, design the dewatering systems to perform as follows:
   1. Prevent damage to adjacent properties, buildings, structures, utilities, and other work as a result of settlement or other groundwater-related effects.
   2. At all times, maintain groundwater levels over the entire excavation a minimum of 3 feet below the excavation grade.

C. At all times, have on the work site sufficient pumping equipment for immediate use, including standby pumps for use in case other pumps become inoperable. Dispose of water 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.

D. Design dewatering system to prevent pumping fines from below grade or disturbing materials exposed at the excavation bottom. Wells shall be cased, and filter(s) shall be provided to prevent such pumping of fines.

E. Provide a sufficient number of monitoring wells to confirm the following:
   1. The dewatering system is performing as intended and is achieving the specified reduction in groundwater levels.
   2. Construction site groundwater levels inside and outside dewatered excavations to determine the acceptability of removing the dewatering system from operation.

F. Furnish container for construction dewatering complete with baffles for the purpose of filtering silt prior to discharge of water. Size container or containers...
to suit dewatering and storage demands.

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

H. Obtain jurisdictional authority’s specific discharge requirements prior to commencement of dewatering.

1.03 SUBMITTALS

A. Submit dewatering plan including shop drawings and design data including the following elements:

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.
6. Methods of disposal of pumped water.
7. Method of water quality monitoring.
8. Type of filtration and chemical treatment of contaminated water, as applicable.
9. Well point system design, if proposed: Submit design complete with calculations and shop drawings.
10. Method for establishing and monitoring construction site groundwater levels.
11. Criteria for determining the acceptability of removing the dewatering system from operation.

B. Prior to removing the dewatering system from operation, submit documentation and calculations verifying that the approved criteria for determining the acceptability of removing the system from operation have been met.

1.04 DELIVERABLES

A. Submit copies of permits required for work of this Section.

1.05 QUALITY ASSURANCE

A. Well point design, if applicable, shall be prepared, signed, and sealed by a geotechnical engineer registered by the State of California and qualified and
PART 2 – PRODUCTS

(Not Used)

PART 3 - EXECUTION

3.01 DEWATERING

A. Except as otherwise indicated in the Contract Documents, perform dewatering to accomplish a lowering of measured static ground water level to an elevation which is suitable for the construction of structures below grade.

B. When pumping is required to reduce groundwater levels, accomplish pumping in a manner that will not disrupt the surrounding environment.

C. Refer to General Provisions 7.10, Sound and Light Control Requirements, for noise control requirements. The Contractor may, during the daylight hours of 8:30 AM to 4:30 PM, use power plants to operate the dewatering pumps. During all other hours, power to run the pumps shall be electric and obtained from the electric power utility in accordance with Section 01590, Construction Facilities, unless otherwise authorized by the Engineer and jurisdictional authorities.

D. If any dewatering well pumps fines, terminate pumping and construct new well at a different location with a revised design which eliminates the pumping of fines.

E. Do not turn off the dewatering system in a manner that the upsurge in water weakens the subgrade for completed excavation and structure foundation work.

F. Remove storage containers, including those cleaned, and other dewatering facilities from the site at the completion of dewatering operations.

3.02 CONTAINMENT, ANALYSIS, AND DISCHARGE OF GROUNDWATER EXTRACTED

A. Containment: Upon extraction, store groundwater extracted in the process of construction dewatering in containers prior to discharge or disposal of water, as applicable. Keep containers locked to prevent accidental or purposeful discharge of the water. 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.

B. Analysis: Collect and analyze water samples taken directly from each storage container to verify that the extracted groundwater meets applicable discharge requirements. Number of samples taken per container shall be at the sole discretion of the Engineer.

C. Discharge Requirements: Discharge no water which exceeds regulatory requirements or the jurisdictional authority’s discharge requirements.

D. Discharge: Obtain jurisdictional authority’s specific discharge requirements prior to commencement of dewatering. Subject to the discharge restrictions specified herein and upon written authorization from the jurisdictional authority, discharge
provide conduits to carry said effluent to nearest sanitary sewer manhole and drainage to the nearest storm drainage. Confirm that manholes to be utilized are in operating condition. Release water in a manner that will not impact the Contractor’s operations.

E. Disposal: In the event that extracted groundwater does not meet the discharge requirements criteria, provide for the disposal of the extracted groundwater in accordance with General Provisions 7.16, Disposal of Material Outside of the Work Site. Clean dewatering containers, piping, pumps, and other dewatering facilities contaminated as a result of the Work.

F. Use: Extracted groundwater of sufficient quality as shown by test data may be used on site with Engineer’s written approval for those purposes approved by the Engineer.

END OF SECTION
SECTION 02300
EARTHWORK

PART 1 – GENERAL

1.01 DESCRIPTION

A. Section includes specifications for earthwork including excavation, trench excavation for underground utilities, ballast and subballast removal, placement of backfill, and construction of embankments. Section also includes requirements for placement of detectable tape for underground utilities.

1.02 REFERENCE STANDARDS

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

2. C136 Sieve Analysis of Fine and Coarse Aggregates
3. D422 Particle-Size Analysis of Soils
4. D1556 Density and Unit Weight of Soil in Place by the Sand-Cone Method
5. D1557 Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lb./cu. ft.)
6. D2487 Classification of Soils for Engineering Purposes (Unified Soil Classification System)
7. D2922 Test Method for Density of Soil and Soil-Aggregate In Place by Nuclear Methods (Shallow Depth)
8. D3017 Test for Moisture Content of Soil and Soil-Aggregate In Place by Nuclear Methods (Shallow Depth)
9. D3740 Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as used in Engineering Design and Construction

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

1. Section 19 Earthwork

1.03 DEFINITIONS

A. Existing Ballast: Granular material in areas of existing tracks, between top of tie and existing subgrade. The depth of existing ballast varies.
B. Degree of Compaction: A percentage of the maximum density obtained by the test procedure presented in ASTM D1557, Method C.
C. Satisfactory Materials: Any material classified by ASTM D2487 as GW, GP, SW, SP, SC, GM, GC, and SM.

D. Unsatisfactory Materials: Materials that do not comply with the requirements for satisfactory materials. Unsatisfactory materials include those materials containing roots and other organic matter, trash, debris, stones larger than 3 inches, and materials classified in ASTM D2487 as PR, OH, OL, CH, MH, and ML. Unsatisfactory material also includes refuse and other material.

1.04 SUBMITTALS

A. Submit the following pothole shop drawings if specifically required in the Special Conditions. Submit shop drawings of potholed pipes, sewers, utilities and other facilities a minimum of two (2) weeks before beginning shoring excavation or underground construction. Show 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 potholes. 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. Label pertinent information relating to the bent, column, footing, track alignment, and other proposed improvements including new or relocated underground facilities (waterline, sewer, storm drain, combined system duct bank, and underdrain). Include footing dimensions, bent skew, stationing, column offsets, and footing elevations. Proceed with no trenching, excavation, or shoring work until the Engineer has accepted potholing shop drawings. Shop drawings shall be prepared at 1:20 or 1:60 scale, sufficient to show the following information:

1. Topography
2. The entire bent and footings
3. Columns adjacent to the potholes
4. The track alignment
5. Other proposed improvements in the vicinity that might be affected by the location of the existing pipe, sewer, utility or other facility

1.05 DELIVERABLES

A. Submit copies of test reports for material properties and compaction as required in this Section.

1.06 QUALITY ASSURANCE

A. Inspection and Testing Agency retained for inspection and testing specified in this Section shall meet the requirements of ASTM D3740.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Imported Backfill shall consist of well-graded sand, gravel, crushed gravel, crushed stone composed of hard, tough and durable particles, and shall contain not more than 10 percent by weight of material passing a No. 200 mesh sieve and no less than
95 percent by weight passing the 3/4-inch sieve. The maximum allowable aggregate size shall be 1 inch. Gradation shall be determined in accordance with ASTM C136 or D422, as applicable.

B. The following materials shall be as specified in the respective Sections of the Caltrans Standard Specifications, except as otherwise indicated:

1. Structure Backfill: Section 19-3.06, Structure Backfill
2. Pervious Backfill: Section 19-3.065, Pervious Backfill Material
3. Slurry Cement Backfill: Section 19-3.062, Slurry Cement Backfill

C. Soil Stabilization Geotextile: Tensar Bi-Axial Geogrid reinforcement or Engineer approved equal.


E. Underground Warning or Detectable Tracer Tape: Terra Tape Reinforced Sentry-Line as manufactured by Reef Industries, or Engineer approved equal. Extra stretch is acceptable if Reinforced type is not available for the color. Uniform color code (per APWA) as follows:

<table>
<thead>
<tr>
<th>Identification</th>
<th>Type</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Line</td>
<td>12” wide Reinforced</td>
<td>Yellow</td>
</tr>
<tr>
<td>Water Line</td>
<td>6” wide Reinforced</td>
<td>Blue</td>
</tr>
<tr>
<td>Electrical Line</td>
<td>12” wide Reinforced</td>
<td>Red</td>
</tr>
<tr>
<td>Sewer, Drain, Irrigation Line</td>
<td>6” wide Reinforced</td>
<td>Green</td>
</tr>
<tr>
<td>Fiber Optics, Signal, Communications Line</td>
<td>12” wide Reinforced</td>
<td>Orange</td>
</tr>
</tbody>
</table>

PART 3 - EXECUTION

3.01 GENERAL REQUIREMENTS

A. Existing Underground Lines and Services: Remove or abandon in place unclaimed, abandoned utilities as indicated on the Contract Drawings.

B. Utilization of Excavated Materials: Use material removed from excavations for backfill, embankment, subgrade, and similar purposes, unless the material is unsatisfactory. Refer to Article entitled "Excess Material" herein for disposal of excess materials.

C. Use existing salvaged ballast for backfill, bedding, embankment, or fill as designated by the Engineer.

D. Erosion Protection: Refer to Section 01560, Temporary Controls, for storm water pollution prevention, dust control, and related requirements. Protect exposed graded areas from wind and water erosion until stabilization is achieved.

E. Perform dewatering as necessary. Refer to Section 02210, Dewatering.

F. Use Soil Stabilization Geotextile for soil stabilization where indicated in the Contract Drawings.
3.02 EXCAVATION

A. Excavate material encountered within the limits of the work, to the lines, grades, and elevations as indicated on the Contract Drawings and as specified herein.

1. In areas where track is to be constructed in the location of an existing track, excavate to the subgrade indicated on the Contract Drawings or bottom of existing ties, whichever is lower.

B. General construction excavation shall not exceed 1 vertical to 1 horizontal slope. If this cannot be accomplished, provide temporary shoring, sheeting and bracing as necessary to retain excavations, maintain banks securely, withstand water pressure, and prevent cave-ins in accordance with Section 02200, Support of Excavation.

C. Perform excavation and placement of fill in a manner and sequence that will provide proper drainage at all times.

D. Surfaces shall be level, or sloped if required, clean, and clear of loose soil. Maintain in good condition until overlying materials are placed.

E. Perform measures to correct over-excavation due to error or careless excavation procedures.

F. Perform structure excavation in accordance with Caltrans Standard Specifications, Section 19-3, Structure Excavation and Backfill.

G. Maintenance of Excavation: When backfill is placed, remove sheeting and bracing in stages so that the walls are supported by the shoring or by newly placed backfill.

3.03 BACKFILL (GENERAL)

A. Place backfill in layers not to exceed 8 inches of loose material, and compact each layer to at least 95 percent laboratory maximum density, in such a manner as to prevent wedging action or eccentric loading.

B. Backfill excavations when installations have been completed, inspected, and approved. Ensure that the following conditions are satisfied prior to proceeding with backfill operations:

1. Concrete has attained sufficient strength to withstand pressure of earth and compacting operation.

2. Excavations are free of forms, debris, and other foreign materials.

C. Place structure, pervious, and slurry cement backfill as specified in the following respective Sections of the Caltrans Standard Specifications, except as otherwise indicated:

1. Structure Backfill: Section 19-3.06, Structure Backfill

2. Pervious Backfill: Section 19-3.065, Pervious Backfill Material

3. Slurry Cement Backfill: Section 19-3.062, Slurry Cement Backfill
3.04 BACKFILL, BEDDING AND FILL FOR CULVERTS, PIPES, AND UTILITIES

A. Bottom of Trench Compaction. Bottoms of excavations shall be firm, undisturbed earth or cut subgrade, clean and free from loose materials, debris, and foreign matter. When bottoms of excavations or trenches are a soft or unstable materials, make bed firm and solid by removing said unstable materials to a sufficient depth and replace same with sand or pea gravel, and compact to a minimum of 90 percent relative compaction. If during construction, soft soils are encountered at depths that make removal impractical, notify the Engineer.

1. Refer to Section 02650, Precast Concrete Culverts, for specific requirements for precast culvert trenches. Refer to Section 15550, Storm Water Lift Stations, for specific requirements for precast vault manhole for pump station.

B. Bedding and Backfill Around Pipes:

1. Before the initial layer of bedding is placed, tamp the bottom surface of the trench or compact bottom surface by plate or other means to provide a base for the bedding.

2. Before the pipe or conduit is laid, place and compact bedding material in conformance to the provisions in Caltrans Standard Specifications, Section 19-3.025, Culvert Beddings. Do not use jetting.

C. Unless specified elsewhere, backfilling for underground utilities shall comply with the following:

1. Replace any unsuitable material with approved backfill material and compact as specified herein. Approved backfill material shall include:
   a. Native excavated material approved to the Engineer
   b. Salvaged track ballast approved by the Engineer
   c. Imported Backfill (if native material or reclaimed track ballast is not available)

2. Place and compact initial lifts in six (6) inch layers maximum uncompacted thickness until 12 inches over pipe. Subsequent lifts may be up to 12 inches in depth prior to compaction. Bring up uniformly on both sides of pipe.

3. Compact foundations for underground utilities and associated structures to not less than 95 percent of the maximum density as determined by ASTM D1557.

4. Place tracer tape (detection tape) one foot above new and recently exposed buried utilities including conduits, fiber optics, communication and signal cables, gas lines, petroleum lines, water lines, and electrical lines. Lay tape flat with three foot of overlap at the end of rolls. If tracer tape depth will exceed tape manufacturer's recommendation, obtain additional instructions from the Engineer before proceeding.

D. Place and compact structure backfill at culverts as specified in this Section under Backfill (General) and as follows:
1. When the level of fill reaches the top of the structure, spread and hand compact two lifts over the structure without traversing the structure with heavy equipment. Begin no compaction with heavy equipment until a minimum of two lifts have been placed, hand compacted, and tested.

2. Back and compact backfill to the same elevation on both sides of the culvert before proceeding to the next layer.

3. When the height of cover indicated on the approved shop drawings or Contract Drawings, as applicable, is 12 inches or less, backfill structure with slurry cement backfill to the top of the structure.

4. In regard to precast concrete culverts, operate equipment over the culvert in accordance with the culvert manufacturer’s recommendation.

E. Keep construction equipment away from edges of excavation a distance equal to the depth of the excavation.

F. Do not place stones larger than 3 inches in backfill around pipes.

G. Refer to compaction and field quality control requirements specified herein for additional requirements.

### 3.05 EMBANKMENTS

A. Clear and grub ground surface on which embankment fill is to be placed of live, dead, or decayed vegetation including trees; rubbish; debris; and other unsatisfactory material in accordance with Section 02110, Site Clearing.

B. Scarify prepared ground surface and moisten or aerate as required just prior to placement of embankment materials to ensure bond between embankment material and the prepared ground surface.

C. Construct earth embankments from satisfactory materials free of organic or frozen material. Use no rocks greater than 3 inches. Place material in successive horizontal lifts of loose material not more than 12 inches in depth. Prior to placement of each layer, moisten or aerate soil surface as necessary and scarified or otherwise broken up in such a manner that the fill will bond with the surface on which it is placed. Uniformly spread layer. After spreading each layer, plow, disk, or otherwise break up layer; moistened or aerated as necessary; thoroughly mix; and compact to at least 90 percent laboratory maximum density, if more than two (2) feet below subgrade elevation, and 95 percent if within two (2) feet of subgrade elevation.

### 3.06 GRADING

A. Grading shall conform to the Contract Drawings and the tolerances specified herein. Transport satisfactory excavated materials to and place in fill or embankment within the limits of grading work. Excavate unsatisfactory materials encountered within the limits of the work and replace with satisfactory materials. Remove unsatisfactory materials and dispose of as specified in the Article entitled “Excess Materials” herein.

B. Finish the surface of excavations, embankments, and subgrade to a smooth and compact surface in accordance with the lines, grades, and cross sections or
elevations shown on the Contract Drawings. Finish grade to within 1/2 inch of the grades and elevations indicated. Finish ditches in a manner that will result in effective drainage.

C. Preparation of Subgrade: Shape subgrade to line, grade, and cross section, and compacted as specified. Shaping subgrade shall include plowing, disking, scarifying existing track subgrade and moistening or aerating required to obtain specified compaction. Remove soft or otherwise unsatisfactory material and replace with satisfactory excavated material or other approved material as directed. Bring low areas resulting from removal of unsatisfactory material up to required grade with satisfactory materials, shape entire subgrade to line, grade, and cross section, and compact as specified. After rolling, the surface of the subgrade shall not show deviation greater than 1/2 inch when tested with a 10-foot straightedge applied both parallel and at right angles to the centerline of the area.

D. Protection and Maintenance of Subgrade:

1. Maintain ditches and drains along subgrade at all times as required to effectively drain the subgrade. Do not disturb finished subgrade by traffic or other operations. Protect and maintain subgrade in a satisfactory condition until ballast, subballast, base, or pavement is placed. Do not store or stockpile materials on the finished subgrade.

2. Obtain Engineer’s inspection and approval of subgrade prior to laying base, subballast, ballast, or pavement. Place no base, subballast, ballast, surfacing, or pavement on a muddy, spongy, or frozen subgrade.

3.07 COMPACTION

A. Do not compact fill or backfill until it has attained the required moisture content. Add an accurately determined and carefully measured amount of water to the materials or surfaces which are too dry. Dry material containing an excess of moisture by manipulation, aeration, drainage, or other means before being compacted. Refer to Field Quality Control field moisture and related testing.

B. When subgrade has been prepared and has reached required grade, proof-roll surfaces to determine if soft spots exist in the material using a 50-ton pneumatic-tired roller or similar approved equipment. If wet or spongy areas are revealed, notify the Engineer so that corrective measures may be determined. Remove soft spots and refill until they meet the required compaction. Proof-roll areas which support the track structure, paving, utility structures, buildings, or other structures in the presence of the Engineer and obtain the Engineer’s approval before further earthwork operations are performed.

C. In addition to proof-rolling, perform field density tests as specified under Field Quality Control herein.

D. Use power-operated or power-driven hand operated equipment wherever possible to compact to requirements specified herein. Do not operate mobile equipment closer to foundation than a horizontal distance equal to the height of backfill above bottom of wall. Accomplish compaction using sheep foot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibrator compactors, or other approved equipment well suited to the type of material being compacted.
E. If the degree of compaction is unsatisfactory, make necessary adjustments until specifications are met. Remove material placed over layers not satisfactorily compacted and re-compact unsatisfactory areas.

F. Unless otherwise noted, relative compaction of fill materials composing each layer of fill shall not be less than 95 percent as determined by ASTM D1556.

G. These compaction requirements do not apply to material placed in stockpiles or waste areas.

3.08 EXCESS MATERIAL

A. Dispose of material authorized to be wasted outside the work site in accordance with GP7.16, Disposal of Material Outside the Work Site, or at waste areas designated on the Contract Drawings, if applicable. Do not dispose of any excavated material in such a manner as to obstruct the flow of any stream, impact wetlands, endanger a partly finished structure, impair the efficiency or appearance of any structure, or be detrimental to the completed work in any way.

B. The following requirements apply to waste sites designated in the Contract Documents for the Contractor’s use:

1. The limits of the storage location will be designated by the Engineer. Keep stockpiles clear of tracks and other facilities, and preventing erosion. Create stockpiles in a manner that does not disturb or damage other work.

2. Construct discrete stockpiles that measure no more than 1000 cubic yards and in a shape that is easily measured by the Engineer or surveyor.

3. Avoid mixing of dissimilar materials. Construct each stockpile of similar material, such as non-impacted overburden soil, obviously compacted soil, or debris. Segregate dissimilar debris materials to facilitate salvage or recycling.

4. Move soil impacted by contaminants around the work site only with the approval of the Engineer.

5. Protect stockpiled soil in accordance with Section 01560, Temporary Controls. Cover stockpiles with plastic sheeting secured against removal by wind or rain. On a daily basis, inspect plastic sheeting covering stockpiles and make necessary repairs.

6. Inform the Engineer each day of the number and locations of stockpiles created that day.

7. When the Engineer has completed sampling from a stockpile, the Engineer will place an identification sign in the stockpile. From that date forward, add no soil to nor remove soil from the stockpile without the approval of the Engineer.

3.09 FIELD QUALITY CONTROL

A. Testing shall be performed by an approved Inspection and Testing Agency retained by the Contractor.
B. Unless otherwise indicated, perform field in-place density testing in accordance with ASTM D1556. Perform field density tests in accordance with ASTM D1556 (Sand-Cone Method). Periodically verify density tests by the nuclear probe method in accordance with ASTM D2922 with density tests from the Sand-Cone method. Minimum number of field density tests shall be as follows:

1. One field density test shall be taken for every 300 linear feet of track for each lift of soil placed and at each grade crossing.

2. One field density test shall be performed for each 1,000 square feet of embankment for each layer of compacted fill.

C. Determine the relative compaction of fill materials composing each layer of fill in accordance with ASTM D1556. Perform testing at same frequency as specified for field in-place density testing.

D. Maximum Dry Density and Optimum Moisture Content: The maximum dry density and optimum moisture content of non-granular soils (greater than 12 percent by weight passing through a No. 200 sieve) shall be determined by one of the methods described in ASTM D1557.

E. Moisture Control: Perform field moisture tests in accordance with ASTM D3017 (Nuclear Probe Method). At the time of compacting, backfill material and the surface on which it is to be placed shall be within plus or minus two (2) percent optimum moisture content and meet specified compaction requirements.

END OF SECTION
SECTION 02310
AGGREGATE BASE COURSES

PART 1 - GENERAL

1.01 DESCRIPTION
A. Section includes specifications for aggregate base courses.

1.02 REFERENCE STANDARDS
A. American Society for Testing and Materials (ASTM International):
   1. D421 Standard Practice for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants
   2. D698 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³))
   3. D1556 Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method

B. State of California, Department of Transportation Standard Specifications (Caltrans):
   1. Section 6, Control of Materials
   2. Section 26, Aggregate Bases

1.03 DEFINITIONS
A. Aggregate Base: Imported material for use in base courses for trackwork, roadway pavement, grade crossings, permanent platforms, sub-ballast, and other locations indicated on the Contract Drawings.

B. Degree of Compaction: Degree of compaction required is expressed as a percentage of the maximum dry density obtained by the test procedure presented in ASTM D698. The compaction required will be abbreviated hereinafter as a percentage of laboratory maximum density.

1.04 SUBMITTALS
A. Submit test reports for field density tests and source quality control tests.

1.05 DELIVERABLES
A. Submit copies of waybills and delivery tickets during the progress of the work. Before the final payment is made, submit certified waybills and certified delivery tickets for all aggregates actually used.
1.06 DELIVERY, STORAGE, AND HANDLING

A. Before stockpiling of material, clear and slope to drain stockpile sites.

B. Stockpile materials obtained from different sources separately.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Aggregate Base (except as used as sub-ballast): Aggregate shall conform to Caltrans Standard Specifications, Section 26, Class 2 Aggregate Base, 3/4 inch maximum gradation.

B. Aggregate Base used as sub-ballast: Aggregate shall conform to Caltrans Standard Specifications, Section 26, Class 2 Aggregate Base, 3/4 inch maximum gradation. In addition, the aggregate shall meet the following additional requirements:

1. Aggregate for sub-ballast shall consist entirely of crushed stone and have at least two fractured faces. No reclaimed asphalt or concrete shall be included in this material.

2. Composition of the aggregate, in percentages by weight, shall conform to the “Operating Range Aggregate Grading Requirements” per Caltrans Standard Specifications Section 26-1.02A.

3. The aggregate shall conform to the “Contract Compliance Quality Requirements” per Caltrans Standard Specifications Section 26-1.02A.

2.02 SOURCE QUALITY CONTROL

A. Perform sampling and tests of the aggregate base material in accordance with the Test Methods specified in Caltrans Section 6-3 to determine compliance with grading, R-value, Sand Equivalent, and Durability Index. Take samples from material as delivered to the site and prepare samples in accordance with ASTM D421 or applicable Caltrans method.

B. Aggregate grading or sand equivalent test shall represent no more than 500 cubic yards of base course material or one day’s production, whichever is the greater amount.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Request Engineer’s inspection of and obtain Engineer’s written acceptance of the prepared subgrade or subbase before proceeding with the placement of aggregate base course.

B. Confirm that immediately prior to spreading base course, the subgrade or subbase to receive aggregate base course conforms to the compaction and
elevation tolerances indicated for the material involved and is free of standing water and loose or extraneous material. Subgrade shall conform to the requirements of Section 02300, Earthwork.

1. Confirm that underlying material has been excavated to sufficient depth to accept the required base course thickness such that the finished base course with the subsequent surface course will meet the final grade.

### 3.02 PREPARATION

A. Prior to installation of base courses, area shall conform to the lines, grades, cross section, and dimensions indicated.

B. Correct areas of underlying course which exhibit ruts or soft and yielding spots and areas having inadequate compaction as specified in Section 02300, Earthwork. Remove and replace soft and yielding spots and areas having inadequate compact with suitable material. Underlying course may be mechanically stabilized with aggregate prior to placement of the base course. Stabilization may be accomplished by mixing base course material into the underlying course and compacting by approved methods. Properly compacted material will be considered as part of the underlying course and shall meet all requirements for the underlying course in accordance with Section 02300, Earthwork.

C. Prevent disturbance of finished underlying course by traffic or other operations and maintain it in a satisfactory condition until base course is placed.

D. Before placing base course, clean underlying course of foreign substances. When the base is constructed in more than one layer, the previously constructed layer shall be cleaned of loose and foreign matter by sweeping with power sweepers or power brooms, except that hand brooms may be used in areas where power cleaning is not practicable.

### 3.03 INSTALLATION

A. Prepare, place, and compact base course in accordance with Caltrans Section 26.

B. Minimum Uniform Compacted Thickness: Minimum compacted thickness shall be 6 inches.

C. The finish of finished aggregate base course at any point shall not vary more than 1/2 inch above or below the indicated grade.

### 3.04 FIELD QUALITY CONTROL

A. Perform field in-place density testing in accordance with ASTM D1556.

B. Frequency of Field In-Place Density Tests: Perform no less than one test for each 2,000 square feet of base course material, per layer or lift.

END OF SECTION
SECTION 02400
UTILITY JACKING AND BORING

PART 1 – GENERAL

1.01 DESCRIPTION
A. Section includes specifications for jack and bore installation of pipe, casing, or conduit.

1.02 SUBMITTALS
A. Obtain Engineer’s approval of the following submittals:
   1. Submit working drawings describing the proposed jack and bore. Include arrangement of equipment; location and size of jacking and receiving pits including their relative location to tracks; method of dewatering; method of monitoring for possible settlement; method to prevent loss of the excavation face; method of removing spoils material; and carrier pipe size, method of fusing pipe segments, and carrier pipe end seals. Include sufficient information to show compliance with the Contract Documents.
   2. Support of excavation for pits: Submit the proposed methods of construction, design, and details for pit excavation shoring systems. Refer to Section 02200, Support of Excavation, for related submittals for support of pit excavation.
   3. Emergency remediation plan:
      a. Identify methods to cut and remove rock, concrete, or timber encountered at the boring face and methods to temporarily bulkhead the face.
      b. Identify remedial measures for limiting damage to existing facilities, impact to tracks, and railroad operations due to ground settlement.
      c. The Contractor must have the resources to execute this plan immediately available.
   4. Submit product data including catalog cuts and other descriptive data.
   5. Experience: Submit list of references substantiating jack and bore installer’s experience.

1.03 DELIVERABLES
A. Submit copies of test reports for material properties and compaction as required in this Section.

B. Incorporate the following data in Record (As-Built) Drawings: As-built survey drawing of completed jack and bore installation including horizontal and profile drawings.

C. Support of excavation for pits: Refer to Section 02200, Support of Excavation, for
related deliverables for support of pit excavation.

1.04 QUALITY ASSURANCE
   A. Jack and bore installer shall have documented experience in successfully completing similar installations within the past five years.
   B. Support of excavation for pits: Refer to Section 02200, Support of Excavation, for related quality assurance requirements for support of pit excavation.

PART 2 - PRODUCTS

2.01 MATERIALS
   A. Materials shall be as indicated in the Contract Documents and the approved submittals.
   B. Cement Slurry, As Applicable: As specified in approved submittals.

PART 3 - EXECUTION

3.01 GENERAL
   A. Verify the actual locations (horizontal and vertical) of all utilities prior to beginning work.
   B. If utilities are to remain in place, provide protection from damage during construction operations.
   C. Excavation and Support of Excavation for jacking and receiving pits shall be in accordance with Section 02300, Earthwork, and Section 02200, Support of Excavation.

3.02 HANDLING OF MATERIAL
   A. Handle pipes, conduits, casing, and ancillary items in such a manner as not to damage the material. Damage to the material, including linings or coatings, shall be repaired to the satisfaction of the Engineer or replaced.
   B. Do not drop or drag pipes, conduits. Handle with rolling slings on skids or with cranes.
   C. Do not use bent or otherwise damaged material shall not be used.

3.03 JACK AND BORE
   A. Perform jack and bore operations in accordance with approved submittals and the following requirements:

      1. The front of the pipe shall be provided with mechanical arrangements or devices that prevent the auger from leading the casing so that no unsupported excavation is ahead of the casing.
      2. The use of water or slurry under pressure (jetting) or puddling shall not be
permitted to facilitate boring, pushing, or jacking operations. Water or slurry used to lubricate the cutter and pipe is acceptable.

3. Unless otherwise indicated in the Contract Documents, or accepted by the Engineer in the approved submittals, pipe, conduit, and casing installation under tracks shall be progressed on a continuous basis without stoppage, except for adding sections, until the leading edge has reached the receiving pit.

B. Stop operations stop for the passage of trains. Employ methods to prevent loss of the excavation face in accordance with approved submittals.

C. Stop operations if ground settlement is detected and employ the emergency remediation plan in accordance with the approved submittals. Repair any damages to the tracks, including track displacement resulting from the construction’s operations. The corrective action shall be approved by the Engineer.

D. With the use of spacers, place the carrier pipe in the casing pipe such that there is equal space between the casing pipe and carrier pipe, and fill the space with cement slurry, unless otherwise indicated in the Contract Documents.

3.04 FIELD QUALITY CONTROL

A. Refer to Section 01400, Quality Control and Assurance. Testing shall be performed by an Engineer-approved Inspection and Testing Agency retained by the Contractor.
SECTION 02500
UNDERGROUND DUCTWORK AND STRUCTURES

PART 1 – GENERAL

1.01 DESCRIPTION

A. Section includes requirements for conduits, precast concrete structures, cast-in-place concrete ductbank and structures, including frames, covers, gratings, steps and sumps, and cover identification.

1.02 REFERENCE STANDARDS

A. American Society of Testing and Materials (ASTM International):
   1. A48 Specification for Gray Iron Castings
   3. A536 Specifications for Ductile Iron Castings
   5. C33 Specification for Concrete Aggregates

B. California Code of Regulations:
   1. Title 24, Part 3 State Electrical Code

   1. 128 Rules for Construction of Underground Electric Supply and Communications Systems

1.03 SUBMITTALS

A. Submit shop drawings for fabrication and installation of precast concrete structures, cast-in-place concrete structures, and concrete-encased underground ductwork, including the following:
   1. Cast-in-place and precast detailed steel reinforcement drawings; and precast manufacturer’s concrete mix designs for structures and colored concrete as indicated.

B. Submit product data including the following:
   1. Complete materials list of items proposed to be furnished and installed under this Section.
2. Manufacturers’ specifications and other data required to demonstrate compliance with these Specifications.

3. Catalog cuts for the following products:
   a. Conduits.
   b. Underground duct system, duct spacers, including manholes, pull boxes, handholes, cable junction boxes, and termination boxes.
   c. Manhole, pull box, and handhole covers and frames.
   d. Related miscellaneous hardware and metal items for cable trenches and wireways.
   e. Trench and wireway covers including composition of FRP materials, divider partition panels, method of joining sections, expansion joint mounting, and support details.

C. Submit concrete mix designs for cast-in-place concrete under Section 03300, Cast-in-Place Concrete. Submit concrete sample showing proposed concrete color for approval.

D. Qualifications: Submit manufacturers’ qualifications.

E. Submit certificates of compliance for all specified products.

1.04 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with the State Electrical Code, and CPUC General Order No. 128. In case of conflict between the State Electrical Code and CPUC G.O. 128, the provisions of CPUC G.O. No. 128 shall govern.

B. Qualification of Manufacturers:
   1. Manufacturers of the products specified for work under this Section shall be in the business of manufacturing similar products and shall be able to provide a history of successful production of the specified products.
   2. Submit a list of five major projects, where similar products have been supplied, which have been in satisfactory use or operation for the past five years.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Conduit and Pull Cord: Provide PVC conduit, minimum Schedule 40, and all necessary fittings, in sizes as indicated, and pull cord as specified in Section 16130, Conduit and Fittings. Provide flared bell ends on conduits and ducts entering manholes, handholes, and pull boxes.
B. Precast Concrete: Provide precast concrete structures in accordance with requirements as indicated in this Section.

1. Precast concrete electrical boxes, pull boxes, ground rod boxes, manholes, handholes, and vaults shall be provided as indicated. Concrete reinforcement shall be that which is regularly provided in standard products of the manufacturer. Standard manufactured structures that meet project requirements will be acceptable. Provide concrete inserts for mounting cable support brackets as indicated.

2. Provide covers with two lifting eyes and two hold-down bolts. Each box shall have a suitable opening for a ground rod, and a drainage opening.

C. Sand: Sand for filler material, where indicated, and for bedding of conduit shall be bedding material specified in Section 02300, Earthwork.

D. Aggregate Base: As specified in Section 02310, Aggregate Base Courses.

E. Cast-In-Place Concrete for Ductbank Encasements, Manholes, Pull Boxes, and Vaults:

1. Concrete shall be Class 3000 in accordance with Section 03300, Cast-in-Place Concrete, for ductbank encasements, manholes, pull boxes, and vaults. Concrete for ductbank encasements shall be colored with a red mineral coloring pigment as specified in Section 03160, Colored Concrete. Color: Red.

2. Formwork and concrete placement shall conform with applicable requirements of Section 03100, Concrete Forming, and Section 03300, Cast-in-Place Concrete.

3. Reinforcing steel, as indicated, shall conform with applicable requirements of Section 03200, Concrete Reinforcing.

2.02 FRAMES, COVERS, STEPS, AND SUMPS

A. Ferrous Castings:

1. Metal used in manufacture of castings shall conform to ASTM A48, Class 35B for Gray Iron, or ASTM A536, Grade 65-45-12 for Ductile Iron.

2. Castings shall be of uniform quality, free from blowholes, shrinkage, distortion or other defects. Castings shall be smooth and cleaned by shotblasting.

3. Minimum tensile strength shall be 35,000 psi.

4. Castings shall be manufactured true to pattern; component parts shall fit together in a satisfactory manner. Round frames and covers shall have continuously machined bearing surfaces to prevent rocking and rattling.

5. Where castings will be subjected to loads of H20 or greater, provide ductile iron castings.
B. Aluminum Castings: Where required to reduce weights of larger covers for ease of handling, such covers may be manufactured of aluminum castings conforming to ASTM B26/B26M, Alloy No. 713.0. Minimum tensile strength shall be 32,000 psi.

C. Manhole Covers: Provide cast, manufactured manhole covers and frames with heavy-duty solid cover (lid) or vented cover (lid). Covers shall be embossed or engraved with nonslip diamond or square cross-hatched pattern.

1. Provide metal covers with embossed or engraved word identification for the enclosed or underground utility.

D. Precast Covers: Precast covers shall have the utility identification stamped into the cover.

E. Cast Iron Manhole Steps: Provide cast, manufactured manhole steps with cross-hatched treads and with anchor configuration appropriate for cast-in-place concrete or precast concrete. Provide steps for installation 12 inches on center in vertical alignment.

F. Ladders: Provide standard-manufactured or custom-fabricated steel ladders as required to meet the conditions indicated. Steel ladders shall be hot-dip galvanized after fabrication.

G. Galvanizing: All ferrous metal items shall be galvanized after fabrication by the hot-dip process in accordance with ASTM A123. Weight of the zinc coating shall conform with the requirements specified under "Weight of Coating" in ASTM A123.

2.03 REINFORCED PLASTIC MORTAR SPACERS (RPM)

A. Duct spacers shall be made from high density polyethylene (not less than 0.96 specific gravity), as manufactured by Formex Manufacturing, Inc., Underground Devices Inc. make, or equal.

B. Duct Spacers:

1. Duct spacers shall be double wall construction. Spacers shall consist of interlocking modules, i.e. bases, intermediates, and caps, designed to provide independent support for each duct.

2. When spacer modules are locked together, openings shall provide approximately 1/16 inch clearance over the outside diameter of the duct. The interior surface of the duct spacer opening shall be convex to prevent kinking of the duct.

3. Configure spacer module openings to ensure the horizontal and vertical separations for each duct as indicated on the Contract Drawings.
PART 3 – EXECUTION

3.01 VERIFICATION

A. Before beginning construction or installation of a section of underground conduit or ductwork, verify that the site is in suitable condition for installing such conduit or ductwork as indicated.

3.02 EXAMINATION AND EXCAVATION, TRENCHING AND BACKFILLING

A. Perform excavation, bedding, and backfilling for underground conduits and structures in accordance with Section 02300, Earthwork, or as indicated.

3.03 INSTALLATION

A. Underground Duct System: Locate duct system, conduit, pull boxes, and manholes as indicated on the Contract Drawings. Comply with applicable requirements of CPUC GO 128.

B. Ductbank Reinforcing Detail:

1. Provide longitudinal reinforcing steel with a minimum total cross sectional area of 0.0018 times the gross area of the ductbank. Maximum spacing of reinforcement bars shall be 18 inches; minimum of one bar in each corner of ductbank.

2. Provide steel tie bars in the transverse direction enclosing the longitudinal bars; minimum size of No. 3 bars; minimum spacing of 12 inches. Minimum clear concrete cover over reinforcement steel shall be 3 inches where concrete is cast directly against earth, and 1-1/2 inches where concrete is cast directly against formwork.

3. Where ductbank enters rigid underground structures, provide reinforcing steel to tie the ductbank to the structure. Provide details indicating method employed to prevent differential settlement from damaging ductbanks.

C. Ducts:

1. Inspect ducts and couplings to ensure that only clean and undamaged pieces are incorporated in the work.

2. Ductbanks or conduits shall have a minimum slope of 3 inches to each 100 feet away from buildings and towards manholes, pull boxes, and handholes, and shall run in straight lines between indicated changes in direction.

3. Individual conduits that are grouped together to form a ductbank shall conform to the standards and requirements specified herein.

4. Accomplish horizontal or vertical changes in direction exceeding ten degrees by long sweep bends having a minimum radius of curvature of 25 feet, except that manufactured bends may be used at ends of short
5. Terminate conduits in end-bells where duct lines enter vaults.

6. Place spacers or space separators not more than 6 feet apart.

7. Install ducts, joints, and space separators according to manufacturer's printed instructions and recommendations.

8. During non-work hours and at locations where installation of conduits and ducts is temporarily suspended or terminated, close ends of ducts with caps or plugs fitted to prevent entry of water or debris. Use caps or plugs designed for that purpose by the conduit manufacturer.

9. During construction, protect partially completed duct lines from the entrance of debris by means of suitable caps or plugs. As each section of a duct line is completed between manholes, handholes, or pull boxes, draw a mandrel through each conduit as specified in Section 16130, Conduits and Fittings, after which draw a brush with stiff bristles through until the conduit is clear of particles of earth, sand, or gravel. Immediately install conduit caps or plugs.

10. Construct the concrete-encased ductbank with 3 inch minimum cover on all sides.

11. Install 1/8 inch or larger diameter pulling cord in ducts including inner ducts. Fasten each cord to pull iron anchorage in pull box, manhole, or vault with 2 feet minimum slack.

12. Place innerduct in communications conduits avoiding excessive tension and deformation of the innerduct. Replace damaged or necked down innerduct. Conform to the manufacturer's installation instructions.

13. Provide metallic numbering tags indicating the conduit number on both ends of all conduit runs.

D. Concrete Structures, General: Install pull box tops flush with sidewalks or curbs. Install 1-1/2 inches above surrounding grades when remote from curbed roadways or sidewalks.

E. Precast Concrete Structures: Install precast electrical boxes, pull boxes, handholes, manholes, and vaults as indicated. Place boxes on 4 inches of compacted sand bedding. Place manholes on 6 inches of compacted aggregate base. Seal conduit, cable, ground rod entrances, and unused openings with cement mortar.

F. Cast-In-Place Concrete Structures:

1. Obtain Engineer's approval of the location of each pull box, manhole, and vault before construction of such structure is started. Construct top,
walls, and bottom of reinforced concrete. Construct walls and bottom of monolithic concrete.

2. Place concrete for pull boxes, manholes, and vaults on well-compacted soil with a minimum of 6 inches of aggregate base. Seal all sumps.

3. Where duct lines enter pull boxes, manholes, and vaults, the sections of duct may be either cast in the concrete or may enter through a square or rectangular opening of suitable dimensions provided in the utility structure. Install cable-pulling iron anchorage in the wall opposite each ductbank entrance.

3.04 REINFORCED PLASTIC MORTAR SPACERS (RPM)

A. Use base pads to ensure specified dimensions between trench floor and bottom of first tier of ducts. Assemble and anchor ducts and duct spacers using reinforcing bars or trench jack and adjusting wedges in accordance with duct spacer manufacturer’s written instructions. Ensure that duct spacing is maintained and that ducts do not float as a result of concrete pour.

B. For each 20 feet length of duct, provide a minimum of four spacer locations. Place duct spacers not more than six feet apart; transmit no vertical load to conduit.

C. For bore spacers where ductwork is installed in casings, refer to Section 16130, Conduits and Fittings.

3.05 FIELD QUALITY CONTROL

A. Notify the Engineer for inspection and sign-off of the following installations:

1. Completed underground installations: Obtain the Engineer’s inspection and acceptance before installation of cable and equipment.

B. Perform corrective work required to obtain approval of underground construction and ductwork.

END OF SECTION
SECTION 02510
UTILITY GRADE ADJUSTMENTS

PART 1 – GENERAL

1.01 DESCRIPTION
A. Section includes specifications for adjusting existing structures to new finish grade including such structures as manholes, vaults, hand holes, drainage structures, and utility valve structures, including raising or lowering and resetting existing frames, covers, grates, and lids. Including adding or replacing riser collars.

1.02 SUBMITTALS
A. Shop Drawings: Submit shop drawings for approval showing modification for raising and lowering of each type of structure frame and cover impacted by the work of this Contract. Provide documentation that the modification can accommodate all loads resisted by the existing structure.

B. Product Data: Submit product data for approval for cast iron and pre-cast risers for adjustment of frames, covers, lids, and grating.

PART 2 – PRODUCTS

2.01 PRODUCTS
A. Provide cast iron or pre-cast concrete riser collars to suit existing structures, to accommodate loads resisted by the existing structure, and in accordance with the requirements of the jurisdictional authority.

B. Miscellaneous Materials: As required and in accordance with the requirements of the jurisdictional authority and the approved shop drawings.

PART 3 – EXECUTION

3.01 ADJUSTMENT OF MANHOLE COVERS, GRATES, AND SIMILAR FACILITIES TO GRADE
A. Adjust existing facilities as shown on the Contract Drawings by raising or lowering to match the new grade line.

B. Construct or alter the structure to the required line and grade.

C. Use approved cast iron or pre-cast concrete riser collar.

D. Adjust frames and covers to new grade.

E. Perform asphalt pavement work after structures have been adjusted to new pavement grade.
F. Maximum adjustment of manhole covers, drainage grates, and valve covers shall be 12 inches plus or minus, unless noted otherwise.

END OF SECTION
SECTION 02620
SUBDRAINAGE SYSTEMS

PART 1 - GENERAL

1.01 DESCRIPTION
A. Section includes specifications for subdrainage systems (underdrains).

1.02 REFERENCE STANDARDS
A. ASTM International (ASTM):
   1. D1784 Rigid PVC Compounds and CPVC Compounds
   2. D3212 Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
   3. F477 Elastomeric Seals (Gaskets) for Joining Plastic Pipe
   4. F949 PVC Corrugated Sewer Pipe with Smooth Interior and Fittings
B. State of California, Department of Transportation Standard Specifications (Caltrans):
   1. Section 19, Earthwork
   2. Section 88, Engineering Fabrics

1.03 SUBMITTALS
A. Manufacturer's data sheet for pipe and fitting materials.
B. Certificate of compliance of the gradation requirements for the granular backfill material included in this Section.
C. Manufacturer's data sheet and samples for filter fabric.

PART 2 - PRODUCTS

2.01 MATERIALS
A. Pipe:
   1. Polyvinyl Chloride (PVC), conforming to ASTM F949, 46 psi pipe stiffness, with double wall construction, PVC resin 12454 B per ASTM D1784.
   2. Joints and Gaskets:
      a. Joints: Push-on type, designed for elastomeric gaskets, ASTM
D3212.

b. Gaskets: Rubber, ring type, ASTM F477.

3. Perforated pipe slot geometry shall provide a minimum inflow area of 0.5 SQ IN per LF. The perforations shall consist of two rows of 3/8" holes at 3" on centers parallel to the longitudinal axis of the pipe. The rows shall be approximately 1-1/2 inches apart but not spaced over more than 155 degrees of the circumference. The rows shall be arranged in a staggered pattern so that all perforations lie at the midpoint between perforations in adjacent rows. The spigot or tongue end of the pipe shall not be perforated for a length equal to the depth of the socket, and perforations shall continue at uniform spacing over the entire length of the pipe.

B. Underdrain Granular Backfill Material: Backfill material for underdrains located within ballasted track areas shall be 3/4-inch round river rocks. Backfill for underdrains located outside ballasted track areas shall conform to the pervious backfill requirements of Caltrans Standard Specification 19-3.065.


D. Cleanouts:

1. Type 1, Schedule 80 PVC, as specified for PVC pipe herein. Provide cast iron bolt down type surface frames and covers adjusted to finish grade

2. Casting for Cleanouts: Cast Iron Frame and Lid, Neenah Foundry Company Floor Box Frame and Lid, or Engineer approved equal. Lid cast with the designation “Clean Out”. Diameter of frame adequate to fit over outer diameter size of underdrain pipe.

PART 3 - EXECUTION

3.01 INSTALLATION

A. General Requirements:

1. Line excavated trench with filter fabric, as shown on the Contract Drawings.

2. Unless otherwise indicated, excavate trench and backfill in accordance with Section 02300, Earthwork.

3. Cap cleanout within track ballast at the surface opening.

B. Preparation of Trench Bottom:

1. Unless otherwise indicated, excavate trench bottom to an elevation 6 inches below bottom of pipe.

2. Fill trench bottom to the bottom of pipe grade with underdrain backfill
material to ensure complete and continuous support for the barrel of the pipe.

3. Excavate bell holes to size necessary to accommodate joint.

C. Placement:

1. Lay pipes in the upstream direction to the lines and grades shown, with the bell point upgrade, and with perforations down.

2. Keep interior surfaces of pipes clean during placement. Block pipe ends with pipe caps or plugs to prevent filter material from entering the pipes.


4. Prevent flooding the pipe trench before backfilling operations.

D. Unless otherwise indicated on the contract drawings, place granular backfill material for bedding uniformly along each side of the pipe in minimum widths of 6 inches, and a minimum depth of 12 inches above the top of pipe, after compaction. Space each layer to eliminate voids.

E. Make connections of solid wall outlet pipes to existing structures in accordance with Section 02630, Storm Drainage System.

3.02 FIELD QUALITY CONTROL

A. Notify and obtain Engineer’s approval of pipes and accessories before lowering pipe into the trenches. Replace defective, damaged, or unsatisfactory pipes and accessories.

B. After pipe is laid and joined, notify and obtain Engineer’s approval prior to backfilling. Take up and re-lay or replace, any pipe found to be out of alignment, unduly settled, or damaged.

END OF SECTION
SECTION 02630
STORM DRAINAGE SYSTEM

PART 1 - GENERAL

1.01 DESCRIPTION
A. Section includes specifications for storm drainage systems including modifications and connections to existing storm drainage systems.

1.02 REFERENCE STANDARDS
A. American Association of State Highway and Transportation Officials (AASHTO):
   1. M36 Specification for Corrugated Steel Pipe, Metallic-Coated, for Sewers and Drains
   2. M190 Specification for Bituminous-Coated Corrugated Metal Culvert Pipe and Pipe Arches
   3. M218 Specification for Steel Sheet, Zinc-Coated (Galvanized), for Corrugated Steel Pipe

B. American Society of Testing and Materials (ASTM International):
   1. A36 Specification for Carbon Structural Steel
   2. A48 Specification for Gray Iron Castings
   3. A307 Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
   5. C76 Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
   6. C150 Specification for Portland Cement
   7. C270 Specification for Mortar for Unit Masonry
   9. C478 Specification for Precast Reinforced Concrete Manhole Sections
   10. C882 Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete By Slant Shear
11. D1785 Specification for Polyvinyl Chloride (PVC) Sewer Pipe and Fittings
13. D2855 Practice for Making Solvent-Cemented Joints with Polyvinyl Chloride (PVC) Pipe and Fittings

C. American Water Works Association (AWWA):
1. C111/A21.11 Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
2. C115/A21.15 Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges

D. State of California Department of Transportation Standard Plans (Caltrans)
E. State of California Department of Transportation Bridge Design Specifications (Caltrans)

1.03 SUBMITTALS
A. Submit manufacturer’s data for pipe, structures, trench drains, and appurtenances.
B. Submit trench drain installation procedure including anchor method.

PART 2 – PRODUCTS

2.01 PIPE
A. Reinforced Concrete Pipe:
1. Pipe: ASTM C76, bell and spigot type, Class V, Wall C, unless otherwise indicated
2. Rubber Gaskets: ASTM C443, oil resistant.
3. Cement for Concrete Pipe: ASTM C150, Type II
B. Polyvinyl Chloride (PVC) Pipe:
1. Pipe: ASTM D1785, Type I, Schedule 80
2. Provide fittings, such as adapters, couplings, tees and caps of same material as pipe
3. Cements: ASTM D2564
C. Ductile Iron Pipe:
1. Pipe: AWWA C151, Class 56. Cement lining is not a requirement for ductile iron being used for storm drainage.

2. Joints: AWWA C111, push-on type.

D. Corrugated Metal Pipe:

1. Pipe: AASHTO M36, Type II. Metal thickness shall be 12 gage for 36 inch diameter pipes or larger and 14 gage for smaller diameter pipe. Pitch shall be 2-2/3 inch by 1/2 inch. Pipe, coupling bands and other components shall be bituminous coated in accordance with AASHTO M190.

2. Corrugated metal coupling bands: AASHTO M36, Section 20. Coupling bands may either be one or two piece construction. Coupling bands shall not be more than two thickness' (as listed in AASHTO M218, Table 4), lighter than the thickness of the pipe to be connected and in no case lighter than 0.064 inch. Bolts and nuts for coupling bands shall conform to ASTM A307.

2.02 DRAINAGE STRUCTURES

A. Unless otherwise indicated, precast concrete drainage structures shall conform to ASTM C478, supplemented by the following:

1. Portland cement: ASTM C150, Type II A

2. Mastic gaskets at joints of precast concrete sections shall be Kent Seal No. 2 joint sealant or Engineer approved equal.

B. Fabricate precast concrete catch basins to the sizes indicated on Contract Drawings. Unless otherwise indicated by in Contract Drawings, catch basins shall have a minimum sump of 24 inches measured from the lowest inlet/outlet pipe invert indicated on the Contract Drawings to the bottom slab of the structure (interior face).

C. Drainage inlets (Catch Basins or Grate inlets): Caltrans Standard Plans, Drainage Inlet, Standard Type G1, unless otherwise noted. Drainage inlets may be cast-in-place concrete or equivalent precast inlets.

D. Fabricate frames and covers with provisions for adjustment to grade.

2.03 CEMENT MORTAR

A. Cement mortar: ASTM C270, Type M, fabricated with ASTM C150, Type IIA Portland Cement. Use cement mortar for brick and concrete work, grout collars for pipe connections to structures, lifting holes and other locations indicated in the Contract Documents.

2.04 NON-SHRINK GROUT

A. Non-metallic, fast setting, waterproof, non-shrink, cement-based.
B. Minimum compressive strength at 28 days: 5000 psi.

C. Minimum bond strength: As required to store full bond to reinforcing bars and concrete surfaces, but not less than 3000 psi at 7 days per ASTM C882.

D. Wire Mesh Wrapping: 12 gauge galvanized steel; 2 inches square welded grid pattern.

E. Bonding Agent: Solvent-free moisture-insensitive structural epoxy adhesive; recommended for bonding fresh concrete or repair mortar to steel or hardened concrete.

2.05 FRAMES, COVERS, AND GRATINGS FOR DRAINAGE STRUCTURES


B. Provide appropriate Caltrans standard grates for Caltrans standard inlets. Where standard inlets of a jurisdictional authority are used, provide frames, grates, and covers in accordance with that jurisdictional authority’s standards.

C. Place concrete collars around all drainage structure castings.

2.06 TRENCH DRAINS AND DOWN SPOUTS

A. Trench Drain and Down Spout: ASTM A36. Comply with ADA guidelines; 1/2 inch maximum slot openings. Trench trough, overlap splice, anchors, and down spout pipe shall be steel, galvanized after assembly of each trench section. Fabricate trench drain corners using mitered sections of trough, welded. Trench drain trough and trench grate shall be as shown in the Contract Documents or equal.

1. Trench drain trough: 11 gage steel
2. Down spout pipe wall thickness: 0.12 inches
4. Cast aluminum trench grates: ASTM B26

PART 3 - EXECUTION

3.01 PIPE INSTALLATION

A. General:

1. Perform trench excavation, backfill, and related earthwork as specified in Section 02300, Earthwork.
2. Examine each pipe prior to laying. Use no defective or damaged pipe. Lay pipe to the elevations, inverts, grades, and alignment as indicated on the Contract Drawings.

3. Provide proper equipment for lowering sections of pipe into trenches.

4. Under no circumstances lay pipe in water. Do not lay pipe when trench conditions or weather are unsuitable for such work.

B. Laying Pipe:

1. Lay corrugated metal pipe with the outside laps of circumferential joints pointing upstream and with longitudinal laps on the sides. Cut pipe requiring cutting by mechanical means only (no torch burning or cutting is allowed). Remove burrs and ragged edges from edges of cut pipe.

2. Lay pipe upgrade, unless otherwise noted.

C. Joining Pipe:

1. Lay drainage pipe with the separate sections joined firmly together.

2. Keep the space between the pipe and connecting bands or joints free from dirt and grit so that the connections fit snugly.

3. Protect jointing materials from the air and sun to prevent drying or deterioration.

4. Join PVC pipe in accordance with ASTM D2855.

D. Repair or Replacement of Pipe:

1. Repair bituminous coating on corrugated metal pipe and connecting bands that has been damaged or scored during culvert installation equal to original coating prior to backfilling. Make repairs in accordance with the manufacturer’s specifications.

2. Remove and replace pipe which has been damaged to such extent that satisfactory field repairs cannot be made.

3.02 DRAINAGE STRUCTURES

A. Set drainage structures in the proper location at the invert elevations indicated on the Contract Drawings with rim at the proper elevation. Set structures plumb and true on well compacted gravel base. Provide for adjustment of frames and covers using precast concrete rings or bricks, with a cement mortar or non-shrink grout to close the opening between the frame and structure. Under no condition remove a portion of the structure to allow adjustment of the frame and cover or grate to the proper grade.

B. Install precast reinforced concrete drainage structures in a manner to ensure watertight construction. Repair or replace precast concrete units as required to obtain watertight construction. Install risers and tops using approved gaskets.
for sealing joints. Install units level and plumb. Prevent water from rising over newly made joints until after joints have been inspected and accepted. Make joints water tight.

C. Perform field cutting of openings in the precast utility structure risers so as not to damage the riser. Replace damaged risers. Install risers and tops with the steps in alignment.

D. Install catch basins so as to preclude sediment from any tributary areas from entering the basins until such areas have been stabilized.

E. Where new pipe manholes or pipe inlets are located in areas to be paved or surfaced, construct no individual structure to final grade until the paving or surfacing has been completed immediately adjacent to said structure.

3.03 EXISTING DRAINAGE SYSTEMS

A. Cleanly cut new openings in existing drainage structures, to accept new pipe. Carefully install the new piping and join the new pipe to the existing structure. Make connection using an appropriate saddle where indicated in the Contract Drawings, or grouted as required to provide a neat, sturdy, watertight connection. Make connection in accordance with the standards of the agency having jurisdiction over storm drainage system. Repair any existing or new pipes or structures damaged as a result of the Contractor’s work.

B. Seal abandoned storm drain lines which are not removed with masonry plugs.

END OF SECTION
SECTION 02650
PRECAST CONCRETE CULVERTS

PART 1 – GENERAL

1.01 DESCRIPTION
A. Section includes specifications for concrete three-sided arch culverts with headwalls and wingwalls. Headwalls and wingwalls may be precast or cast-in-place.

1.02 REFERENCE STANDARDS
A. American Railroad Equipment and Maintenance-of-way Association (AREMA):
   1. Manual for Railway Engineering and Maintenance (Manual),
B. American Society for Testing and Materials (ASTM International):
   1. C39 Test Method for Compressive Strength of Cylindrical Concrete Specimens
   2. C497 Test Methods for Concrete Pipe, Manhole Sections, or Tile
C. Caltrain Standards for Design and Maintenance of Structures

1.03 DESIGN REQUIREMENTS
A. Comply with requirements indicated in the Contract Documents.

1.04 SUBMITTALS
A. Shop Drawings. Submit shop drawings for Engineer’s approval including the following information for footings, culvert section, wingwalls, and headwalls, as applicable:
   1. Concrete dimensions, elevations, and reinforcing steel with bar size and spacing indicated. Include elevation, plan, and section views. Include anchorage details, as applicable.
   2. Details for pedestals.
   3. Note actual soil bearing pressure on the footing detail sheets.
   4. Structure backfill type and limits for culvert and wingwalls.
B. Submit manufacturer’s product data of the culvert system for approval. Include adhesive for securing plugs in handling holes.
C. Submit sample showing proposed wingwall finish.
D. Submit design computations for culverts including wingwalls and pedestals. Furnish a longhand example of the design methodology if the design calculations are in a computer printout format.
1.05 QUALITY ASSURANCE

A. Design computations and shop drawings shall be signed and sealed by a professional engineer registered in the State of California.

PART 2 – PRODUCTS

2.01 GENERAL

A. All products necessary to complete the work shall conform to the relevant sections of these technical specifications.

B. Sealer and Waterproofing Membrane: As recommended by culvert manufacturer and approved by the Engineer.

2.02 FABRICATION

A. Handling devices or holes will be permitted in each culvert or wingwall section. However, not more than four holes shall be cast or drilled in each section. Cast holes shall be tapered.

B. Design and form section ends so that when the culvert sections are erected, they shall make a continuous line of culvert with a smooth interior free of irregularities.

C. Joints: Provide keyway joints between culvert sections. Keyway joint shall be a minimum of 4 inches deep by 1-1/2 inches wide.

D. The culvert sections and wingwalls shall be free of fractures. The ends of the culvert sections shall be normal to the walls and centerline, except where beveled ends are specified. The surface of the culvert section shall be a smooth steel form or troweled surface. Trapped air pockets causing defects which do not weaken or make sections more vulnerable to corrosion shall be considered as part of a smooth steel form finish.

E. Provide smooth rubbed finish on wingwalls. Refer to Section 03170, Concrete Finishing.

F. Do not store culvert units in an upright position until the designated handling and storage compressive strength, as shown on the shop drawings, has been achieved.

G. Marking: Clearly mark each culvert section and wingwall with waterproof paint. The following information shall be shown on the inside face of each wingwall and on a vertical leg of each culvert section:

1. Culvert span and rise (culvert sections only)
2. Date of manufacture
3. Name or trademark of manufacturer
4. Design earth cover
5. Location designator for use in field
2.03 SOURCE QUALITY CONTROL

A. Test Specimen: Determine concrete compressive strength from compression tests made on cylinders or cores. For cylinder testing, take a minimum of 4 cylinders during each production run. For core testing, cut one core from a culvert section selected at random from each group of 15 culvert sections or less of a particular size and production run. Cut one core from each group of four or fewer wingwalls. For each continuous production run, each group of 15 culvert sections of a single size or fraction thereof or four wingwalls shall be considered separately for the purpose of testing or acceptance. A production run shall be considered continuous if not interrupted for more than three consecutive days.


C. Acceptability of Cylinders Tests: Failure of one of the 28 day test cylinders to achieve 90 percent of the minimum compressive strength requirement may be cause for rejection.

D. Acceptability of Core Tests: The compressive strength of the concrete in each group of sections as defined above will be acceptable when the core test strength is equal to or greater than the design concrete strength. The Engineer will randomly select and witness testing of the cores taken by the manufacturer.

E. If compressive strength of a core is less than the design concrete strength, the culvert section or wingwalls from which that core was taken will be rejected. The Engineer will select two culvert sections or wingwalls from the remainder of the group at random, and one core shall be taken from each. If the compressive strength of both cores is equal to or greater than the design concrete strength, the remainder of the culvert sections or wingwalls in that group will be acceptable. If the compressive strength of either of the two cores tested is less than the design concrete strength, the remainder of the culvert sections or wingwalls in the group will be rejected. However, at the option of the manufacturer, each remaining culvert section or wingwall in the remainder of the group may be cored and accepted individually. The sections which have cores with less than the design concrete strength will be rejected.

F. Plugging Core Holes in Accepted Units: Plug and cure core holes at place of manufacture in such a manner that the culvert will meet all the test requirements of the specifications. Culvert sections or wingwalls repaired accordingly will be considered satisfactory for use.

G. Test Equipment: Furnish facilities and personnel necessary to conduct the quality control tests required.

2.04 INSPECTION

A. Rejection: Culvert sections or wingwalls will also be rejected due to the following conditions.

1. Fractures or cracks pass through the wall, except for a single end crack which does not exceed half of the thickness of the wall.

2. Defects which indicate proportioning, mixing, or molding which are not in accordance with specifications.
3. Honeycombed or open texture.

4. Damaged section ends, where such damage prevents making a satisfactory joint.

2.05 REPAIRS

A. Repair or replace culvert sections and wingwalls which have manufacturing imperfections or have been damaged. Repairs shall be sound, properly finished and cured, and repaired culvert section or wingwalls complies with the requirements specified herein.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Bottom of Trench Compaction: Compact soils in the bottom of the excavation to 95 percent of the maximum dry density. If 95 percent of the maximum dry density cannot be obtained in the bottom of the excavation or in other areas or if soft soils are encountered at depths that make removal impractical, contact the Engineer for additional requirements.

B. Footings: Footings may be cast-in-place or precast. When a precast footing is utilized, a four (4) inch layer of pervious backfill shall be placed under the full width of the footing. Give footings a smooth form finish. The footing concrete shall reach a compressive strength indicated on the shop drawings before placement of the culvert sections or wingwalls.

C. Pedestals: When a cast-in-place reinforced concrete pedestal is required between the base of the culvert leg and the top of the footing, either provide a culvert with longer legs or construct pedestals, at the Contractor's option.

D. Placement of Culvert Sections and Wingwalls: Set culvert sections and wingwalls on masonite or steel shims. Provide a minimum gap of 1/2 inch between footing and bottom of each section or wingwall. Fill gap with a slurry cement backfill in accordance with Section 02300, Earthwork.

E. Sealing: Apply sealer on the top surface of the culvert section. Such sealer shall extend 5 feet vertically down each vertical leg. Place no sealer material in keyway joints. Provide sealer for the full length of the structure. Prepare surface and apply sealer as recommended by sealer manufacturer.

F. Keep waterproofing membrane in its proper location over joints and protect from damage during the backfilling operation.

G. Prior to backfilling, treat handling holes as follows: Fill tapered holes for handling with Portland cement mortar or precast concrete plugs secured with Portland cement mortar or other adhesive, as approved. Fill drilled holes for handling filled with Portland cement mortar. Prior to backfilling the structure, cover holes with waterproofing membrane with a minimum width of 9 inches.

H. Place and compact structure backfill as specified in Section 02300, Earthwork.

END OF SECTION
SECTION 02700
STATION PLATFORMS, SIDEWALKS, CURBS AND GUTTERS

PART 1 – GENERAL

1.01 DESCRIPTION
A. Section includes requirements for cast-in-place concrete station platforms, sidewalks, curbs, and gutters.

1.02 REFERENCE STANDARDS
A. Standard Specifications for Public Works Construction (SSPWC):
   1. Section 201 Concrete, Mortar, and Related Materials
   2. Section 303-5 Concrete Curbs, Walks, Gutters, Cross Gutters, Alley Intersections, Access Ramps, and Driveways
B. State of California, Department of Transportation, Standard Specifications (Caltrans):
   1. Section 51 Concrete Structures
   2. Section 90 Portland Cement Concrete

1.03 SUBMITTALS
A. Submit concrete mix designs as specified under Section 03300, Cast-in-Place Concrete.
B. For station platforms, comply with the submittal requirements specified in Section 03200, Concrete Reinforcing, Section 03300, Cast-In-Place Concrete, and Section 03160, Colored Concrete.

1.04 DELIVERABLES
A. For station platforms, comply with the deliverable requirements specified in Section 03200, Concrete Reinforcing and Section 03300, Cast-In-Place Concrete.

PART 2 - PRODUCTS

2.01 MATERIALS
A. Sidewalks, Curbs, and Gutters: Materials shall be as specified in SSPWC, Section 201, and as otherwise specified herein.
B. Station Platforms: Materials shall be as specified in Section 03300, Cast-in-Place Concrete, including polypropylene fibers. Concrete shall be integrally colored in accordance with Section 03160, Colored Concrete. Color shall match Quality Concrete Integral Color “Satin Gray”, unless otherwise indicated in the Contract Documents.
C. Type A Joint Seal Material: As specified in Caltrans Standard Specifications, Section 51-1.12F, Sealed Joints, with the following exception: If two (2) part polyurethane sealant is proposed, it shall be the type specified in Section 51-1.12F or equal.

D. Joint Sealant for Station Platforms: Joint sealants shall be type specified in Section 07920, Joint Sealants. Provide in color to match colored concrete.

E. Moisture Barrier for Contact Joints: Curing compound, conforming to requirements in Caltrans Standard Specifications, Section 90-7.01B.

F. Formwork: As specified in SSPWC, Section 303-5, except as otherwise required by the jurisdictional authority.

G. Reinforcing: Refer to Section 03200, Concrete Reinforcement, for reinforcement of station platforms and concrete pavement, as applicable.

PART 3 - EXECUTION

3.01 GENERAL

A. Construct in accordance with SSPWC, Section 303-5, except as otherwise required by the jurisdictional authority and as otherwise specified herein.

B. Construct station platforms as specified in Section 03160, Colored Concrete.

3.02 SUBGRADE

A. Perform in accordance with the requirements of Section 02300, Earthwork, and the following:

1. Immediately prior to placing concrete, subgrade to receive pavement shall conform to compaction and elevation tolerances specified for the material involved.

2. Construct true to grade and cross sections, thoroughly water and roll, or hand tamp until hard and solid. Remove soft, spongy or other unsuitable material to provide stable subgrade at least 6 inches below required subgrade elevation. Deposit approved fill material in low areas, compact thoroughly and grade to required finish subgrade elevation.

3. Subgrade shall be uniformly moist, and any excess water standing in pools or flowing on the surface shall be removed prior to placing concrete.

B. Provide templates for testing grade and cross section of subgrade. Extend template full width between forms and support on side forms.

3.03 CONTACT JOINTS

A. Contact joints are those made by placing fresh concrete against hardened concrete. Apply moisture barrier to the face of contact joint and allow to dry prior to placing fresh concrete against that joint face.
3.04 CURB CONSTRUCTION

A. Construct top and face of the finished curb true and straight. Construct top surface of curbs a uniform width, free from humps, sags, or other irregularities. When a straightedge 10 feet long is laid on the top face of the curb or on the surface of gutters, the surface shall not vary more than 1/8 inches from the edge of the straightedge, except at grade changes or curves.

END OF SECTION
SECTION 02720
ASPHALT PAVING

PART 1 - GENERAL

1.01 DESCRIPTION
A. Section includes specifications for hot-mix asphalt concrete (HMAC) track underlayment and asphalt concrete (AC) paving. Track underlayment includes all areas under the track, and the HMAC becomes part of the track structure.

1.02 REFERENCE STANDARDS
A. State of California, Department of Transportation, Standard Specifications (Caltrans):
   1. Section 39 Asphalt Concrete
   2. Section 88 Engineering Fabrics
   3. Section 93 Liquid Asphalts
   4. Section 94 Asphaltic Emulsions

1.03 SUBMITTALS
A. Submit Certificate of Compliance confirming that the asphalt concrete mix is in accordance with the requirements of this Section.
B. List of equipment to be used for the placing, spreading, and compaction of asphalt paving on structures. Only equipment approved by the Engineer shall be used.

1.04 DELIVERABLES
A. Submit records of delivery of asphalt materials, identifying shipment numbers, dates and quantities, material designations and temperature at the time of placement.
B. Submit copies of aggregate tests, penetration of the asphalt cement, and percentages by weight and number of pounds of each of the materials making up the batch.

PART 1 – PRODUCTS

2.01 MATERIALS
A. The material for HMAC and AC pavements shall conform to the provisions of Caltrans Standard Specifications, Section 39-2, “Materials”.
B. HMAC pavement for track underlay: Type A with 3/4-inch maximum, coarse aggregate gradation. Asphalt binder shall be steam refined AR-8000 grade in accordance with Section 92 of the Caltrans Standard Specifications.
C. AC pavement: Type A with 1/2-inch maximum, coarse aggregate gradation. Asphalt binder shall be steam refined AR-4000 or AR-8000 grade in accordance with Section 92 of the Caltrans Standard Specifications.

D. Prime coat: Emulsified asphalt Type RS-2 conforming to Caltrans Standard Specifications, Section 94, Asphaltic Emulsions.

E. Binder coat (tack coat) shall be Type SS-1 conforming to the provisions of the American Asphalt Institute Specifications and Caltrans Standard Specifications, Section 94, Asphaltic Emulsions. Binder coat for use with pavement reinforcing fabric shall also comply with requirements specified in Caltrans Standard Specifications, Section 39-2.


PART 3 – EXECUTION

3.01 PREPARATION

A. HMAC pavement for track underlay: Subgrade shall be prepared and compacted to the requirements of Section 02300, Earthwork. Confirm that immediately prior to spreading HMAC, the subgrade to receive HMAC conforms to the compaction and elevation tolerances indicated and is free of standing water and loose or extraneous material. Request Engineer's inspection of and obtain Engineer's written acceptance of the prepared subgrade before proceeding with the spreading of HMAC.

B. Obtain written approval of aggregate base course from the Engineer prior to proceeding with paving. Refer to Section 02310, Aggregate Base Courses.

C. Refer to Section 02510, Utility Grade Adjustments, for related work.

3.02 SPREADING

A. Spread HMAC underlay by either a mechanical spreader or a grader. Maximum length of asphalt mixture placed by an approved mechanical spreader in a continuous strip shall not exceed 800 feet, unless otherwise permitted by the Engineer. Lay adjacent strips subject to the above limitations immediately after the previous strip is placed until the full pavement width has been achieved. Track underlay may be placed in one lift.

B. Place pavement to the depth shown on the Contract Drawings. Lift thickness shall conform to the following:

1. Final Surface Course or Lift: In areas subject to vehicular traffic, the maximum thickness shall be 2 inches. In all other areas, the maximum thickness shall be 3 inches.

2. Lifts Other Than Final: The maximum thickness shall be 3 inches.
C. Use a paver or approved mechanical spreader. Obtain Engineer’s approval for use of other means of spreading and compaction.

D. Prime pavement or concrete contact surfaces before placing asphalt concrete pavement.

E. Apply prime coat and tack coat prior to placing asphalt concrete in accordance to Caltrans Standard Specifications, Section 39-4, Subgrade, Prime Coat, Paint Binder (Tack Coat), and Section 39-5, Pavement Reinforcing Fabric.

F. Hand Laying Surface Mixture: Dump on approved dumping boards or steel plates and distribute immediately by means of hot shovels. Uniformly spread by means of hot iron rakes with tines not less than 1/2 inch longer than the loose depth of mixture to a depth which, after final compaction, shall be of the thickness required. Permit no walking on the surface mixture during the laying operations. If laid by hand, carefully lute surface mixture, after spreading and raking, from the sides before compaction.

3.03 COMPACtion

A. Rollers:

1. Steel-wheeled, tandem type power driven rollers shall provide a pressure of not less than 225 pounds per inch width of main roll. Rolls shall be smooth and without flat spots or other imperfections.

2. Pneumatic rubber-tired rollers shall be self-propelled with wheels mounted, grouped and spaced to provide uniform coverage with each pass. Rear group wheels shall not follow in the tracks of forward group wheel. Maximum wheel load shall be 5,600 pounds. Tire compression on pavement, where the area of contact is measured on a hard, unyielding surface, shall be 80 psi plus five (5) psi for each wheel. The total maximum load per axle, whether single axle or a group of axles in the same alignment, shall be 22,400 pounds. Wheel loads and tire pressures shall be controlled to produce the required degree of compaction without rutting of the surface to be rolled.

B. Rolling:

1. Proceed continuously at the following rates:

   a. For track underlay mixture, when spread by hand, not in excess of 400 square yards per hour, per roller.

   b. For track underlay, when spread by machine, not in excess of 600 square yards per hour, per roller.

   c. For asphalt concrete surface mixtures, when spread by hand, not in excess of 300 square yards per hour, per roller.

   d. For asphalt concrete surface mixtures, when spread by machine, not in excess of 400 square yards per hour, per roller.
2. Immediately after spreading, thoroughly compact by approved tamping irons adjacent to curbs, manholes and rails, by rolling with approved rollers continuously from commencement to final completion at a speed not exceeding three (3) miles per hour.

3. Make initial rolling, using tandem type rollers, parallel to the center line of the paved surface beginning at the curbs or edges of the paved surface and working toward the center, overlapping on successive trips by one-half the rear wheel of the roller. Immediately following the initial rolling, further compact by pneumatic rubber-tired rollers or steel wheel vibratory tandem type rollers a minimum of eight (8) passes, except HMAC track underlay which shall receive 4 passes. Smooth shallow ruts and ridges with tandem rollers immediately following the rubber-tired rolling.

4. First make final roll longitudinally with the paved surface and then diagonally or at right angles. Continue until no further compression results; the mixture has cooled; no marks show under the roller; and the surface is smooth and free from depressions, waves, bunches, and unevenness.

5. Test after the mixture has been rolled with an approved straight edge and surface testing machine laid parallel to the centerline of the paved surface.

3.04 JOINTS

A. Lay surface mixture in a continuous operation and pass the roller over the unprotected end of the freshly laid mixture only when laying of the course is to be discontinued for such length of time as to permit the mixture to become chilled. Provide for proper bond with new mixture by cutting or trimming back the joint to expose an unsealed or granular surface for the full specified depth of the course.

B. At the end of each day’s work, form joints by laying and rolling against boards of the thickness of the compacted mixture, placed across the entire width of the pavement.

C. When the laying of the mixture is resumed, remove the boards, paint the exposed edge of the joint with a thin coat of approved hot asphalt cement or liquid asphalt, rake a fresh mixture against the joint, thoroughly tamp and roll. Hot smoothing irons may be used for sealing joints.

3.05 LAYING IN DAYLIGHT, WET WEATHER, COLD WEATHER

A. Schedule placement of asphalt paving material when the precipitation probability within 3 hours prior to the start of such operations is less than 50 percent.

B. Laying of mixtures will not be permitted in wet weather.

C. Except where otherwise permitted by the Engineer, spread no asphalitic mixtures when the asphalt mixture temperature is below 250 degrees F.

D. The Engineer will take surface temperatures at three (3) locations in the area being paved. The controlling temperature shall be the average of the three (3) readings.
3.06 OPENING TO TRAFFIC
   A. Repair damage to new pavement caused by construction equipment or by public
      traffic due to premature opening of the traffic lanes to the satisfaction of the
      Engineer.

3.07 SURFACE PREPARATION
   A. When pavement overlay or new pavement is to be constructed on an existing asphalt
      concrete, concrete, or brick surface, broom the existing surface clean prior to the
      application of prime coat. Repair holes and depressions in existing surfaces by
      removal to sound material and replacing with an asphalt-aggregate patching
      material. Compact patch to produce a tight surface conforming to the adjacent
      pavement area. Stabilize rocking Portland cement concrete slabs by undersealing or
      cracking and seating. Make the necessary repairs before brooming and prime
      coating. Fill wide joints and cracks with asphaltic concrete/sand mix material and
      compact as required by the Engineer.

3.08 DEFECTIVE WEARING COURSE
   A. Remove portions of the completed wearing course that are defective in finish,
      compression, composition, or density and replace with suitable material properly laid
      in accordance with these Specifications.

END OF SECTION
SECTION 02740
WHEEL STOPS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Section includes specifications for precast concrete wheel stops for vehicular parking stalls in parking structures and parking lots as indicated.

1.02 REFERENCE STANDARDS

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

1. Section 95 Epoxy

1.03 SUBMITTALS

A. Shop Drawings: Submit shop drawings of stops, including installation details and attachment details to at-grade concrete and asphalt pavement, for approval.

B. Product Data: Submit manufacturers’ product data of precast stops and epoxy adhesive for approval.

1.04 QUALITY ASSURANCE:

A. Precast wheel stops shall be manufactured for the intended purpose by a company or firm specializing in the manufacture of precast concrete parking appurtenances.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Wheel Stops: Precast, 3.5% minimum air-entrained concrete; 4000 psi minimum compressive strength. Each stop shall be reinforced with two No. 4 deformed steel reinforcing bars, minimum. Provide chamfered corners and drainage slots on underside, and provide holes for dowel-anchoring to substrate. Unless indicated otherwise, provide stops of half octagonal configuration and 36-inch length.

B. Adhesive for Anchoring Stops to Parking Structure Slabs, At-Grade Concrete Pavements, and At-Grade Asphalt Pavements: Epoxy adhesive manufactured for the purpose, similar and equal to the adhesives specified in Caltrans Standard Specifications, Section 95-2.04 or 95-2.05.

C. Adhesive for Bonding Dowel to Wheel Stop: As proposed by Contractor and approved by the Engineer, suitable for application.

D. Steel Bars for Installation: Galvanized 5/8” diameter steel dowels or galvanized...
No. 5 steel reinforcing bars.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Securely attach wheel stops into at-grade concrete and at-grade asphalt pavement with not less than two galvanized steel dowels embedded in holes cast into wheel stops. Firmly bond each dowel to wheel stop and to pavement.

B. At concrete pavement, drill holes in pavement for dowels.

C. At parking structure slabs, epoxy to slab.

END OF SECTION
SECTION 02780
PAVEMENT STRIPES AND MARKINGS

PART 1 - GENERAL

1.01 DESCRIPTION
A. Section includes specifications traffic stripes, and pavement markings, as well as striping and pavement markings for station platforms.

1.02 REFERENCE STANDARDS
A. State of California, Department of Transportation Standard Specifications (Caltrans):
   1. Section 84 Traffic Stripes and Pavement Markings
B. State of California, Department of Transportation (Caltrans) Standard Plans.

1.03 DEFINITIONS
A. The following definition augments definitions in the Caltrans Specifications:
   1. Platform safety Warning Striping: Yellow warning stripe applied to the platform where indicated on the Contract Drawings.

1.04 SUBMITTALS
A. Submit manufacturer’s product data for materials.

PART 2 - PRODUCTS

2.01 MATERIALS
A. Paint for pavement marking, striping, and platform paint: Paint for traffic stripes as specified in Caltrans Standard Specifications, Section 84-3.

PART 3 - EXECUTION

3.01 PREPARATION
A. Layout of Work: Prior to the application of the striping and pavement markings, mark the location of the striping and pavement markings, and request inspection and obtain Engineer’s approval of the layout before proceeding with the application work.
3.02 APPLICATION

A. Apply paint in accordance with Caltrans Standard Specifications, Section 84-3, Painted Traffic Stripes and Pavement Markings.

END OF SECTION
PART 1 - GENERAL

1.01 DESCRIPTION

A. Section includes requirements for steel fencing and railing at station platforms, including center fencing, handrailing and platform edge railing.

1.02 REFERENCE STANDARDS

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

1. A36 Specification for Carbon Structural Steel


3. A153 Standard Specification for Zinc Coating (Hot-dip) on Iron and Steel Hardware

4. A653 Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process


1.03 SUBMITTALS

A. Submit shop drawings showing plan layout, grid, spacing of components, accessories, fittings and hardware.

B. Submit manufacturer’s product data.

C. Submit manufacturer’s installation instructions.

D. Submit manufacturer’s color palette to the Engineer for approval.

1.04 DELIVERABLES

A. Submit manufacturer’s certificates of compliance for fence materials.

B. Qualifications: Submit name, business address and telephone number of fabricator’s field representative.

C. Furnish certificate of inspection stating that the material has been sampled, tested and inspected per ASTM A653.

1.05 QUALITY ASSURANCE

A. Obtain the services of fencing fabricator’s field representative to provide advice and assistance on the installation of the fence panels, fasteners, and repair work.
1.06 EXTRA MATERIALS

A. Furnish the following extra materials for center fence, and for platform edge railing as follows. Securely fasten the panels and posts on wooden pallets, and the hardware in plastic container clearly marked “Station Fencing/Railing”, and deliver them to the Engineer’s warehouse located within 25 miles of the project site.

1. For station center fence: 2 panels including 2 posts, and all necessary hardware.
2. For station platform edge railing: 4 panels including 4 posts, and all necessary hardware.

PART 2 - PRODUCTS

2.01 FENCE AND GATES

A. Fence panel width, other dimensions, and details including spacing of pickets, rings, posts, details of post caps, fasteners, etc.: see Caltrain Standard Drawing or Contract Drawings.

1. Finished center fence height shall be 6 feet from top of rail of higher adjacent tracks.

B. Posts, rails and hardware:

1. Posts and post caps: Galvanized, square steel tubular members conforming to ASTM A787 and G90 zinc coating.
2. Horizontal rails: Galvanized, square steel tubular members conforming to ASTM A787, 50,000 psi yield strength and G90 zinc coating. Attach rails to posts with tamper resistant fasteners.
3. Hardware (Base Plates, Anchor Bolts, Gate Hardware and Miscellaneous Hardware): ASTM A36.
5. Epoxy Grout: Epoxy grout shall conform to Section 03150, Concrete Accessories.

C. Gate Hardware: Hinges, latches, drop rods, as needed, shall be hot dip galvanized steel in accordance with ASTM A153 and sized to assure proper gate operation.

2.02 CONCRETE

A. Concrete: Concrete shall conform to the following:

1. Portland Cement: ASTM C-150, type 2 or 5 (Low alkali)
2. Aggregates:
   a. coarse aggregates: crushed rock, max 1-1/2 inch, #200: 2% maximum
b. Sand: 3/8 inch maximum, #200: 2% maximum

3. Compressive strength (minimum): 2,500 psi @ 7 days, 4,000 psi @ 28 days

4. Slumps: 2 to 4.5 inches

B. Footing hole shall be clear of roots or other organic materials. Moist hole prior to concrete pour. No water standing at bottom of hole.

C. Consolidate concrete to remove air pockets.

2.03 SHOP FINISHES

A. Galvanizing: Hot dip galvanize fence panels, rails and all associated hardware after fabrication in accordance with ASTM A123. Coating Thickness: Minimum 90 microns, and,

B. Powder Coat: Powder coat all parts of fence including hardware after galvanizing and in accordance with coating manufacturer’s instructions. Powder coat: O’Brien TGIC-Polyester or Engineer approved equal. Color: Black.

PART 3 – INSTALLATION

3.01 INSTALLATION

A. Concrete Footings: Drill or dig holes for post footings in firm, undisturbed or compacted soil or ballast. Towel tops of footings and slope or dome to direct water away from posts. For railing, flush the epoxy with the platform.

B. Field Joints: Field joints shall be kept to a minimum and concealed to the greatest extent possible. Field joints shall be strong, rigid, watertight and flush with hairline fit. Ease sharp corners.

C. Adjust fence for uninterrupted visual continuity and tight, non-rattling connections.

D. For station center fence: Restore ballast to flush with the top of ties.

3.02 REPAIR

A. Welded and abraded areas of galvanized surfaces shall be wire brushed and repaired with 2 coats of cold galvanized compound.

B. Repair abraded or damaged powder-coated per manufacturer’s instructions.

END OF SECTION
SECTION 02810
CHAIN LINK FENCE

PART 1 - GENERAL

1.01 DESCRIPTION
A. Section includes requirements for chain link fence and gates (personal, and swing or sliding gates), either hot-dip galvanized or polymer-coated (over hot-dip galvanizing).

B. Polymer-coated (over hot-dip galvanizing) is installed at locations as indicated on the Contract Drawings, such as where the fence is adjacent to bike path.

1.03 REFERENCE STANDARDS
A. American Society for Testing and Materials (ASTM International):
   1. A123  Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
   2. A153  Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
   3. F668  Specification for PolyVinyl Chloride (PVC) - and Other Organic Polymer-Coated Steel Chain-Link Fence Fabric
   4. A780  Practice for Repair of Damaged or Uncoated Areas of Hot-Dip Galvanized Coatings
   5. F900  Specification for Industrial and Commercial Swing Gates
   6. F934  Specification for Standard Colors for Polymer-Coated Chain Link Fence Materials
   7. F1043 Specification for Strength and Protective Coatings on Steel Industrial Chain Link Fence Framework
   8. F1083 Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures

B. Federal Specification:
   1. RR-F-191/2C  Fencing, Wire and Post, Metal (Chain Link Fence Gates) (Detail Specification)

1.04 SUBMITTALS
A. Submit shop drawings for fencing and gates.

B. Manufacturer's technical data and installation instructions for fencing and gates.
C. Samples: For the polymer-coating, submit manufacturer’s color chart of available colors and physical sample of color.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Fabric: Hot-dip galvanizing conforming to ASTM A123 and A153 as applicable.
   1. Mesh Size and Gauge: 2 inches, 8 gauge wire
   2. Top and bottom salvages twisted and barbed
   3. Tension wire (top and bottom edges): coil spring wire, 7 gauge
   4. Use one piece fabric widths

B. If polymer-coated finish is required, Polymer-coated (over galvanizing) conforming to ASTM F668, Class 1, 2, or 2b, and ASTM F1043. Wire gage specified for polymer coated fabric shall be the steel core wire, not the finish coated diameter. Color: Black in accordance with ASTM F934, unless otherwise indicated.
   1. Fuse and adhere a minimum 10-mil (0.254 mm) PVC coating or polyolefin coating to the zinc exterior coating of the framework.
   2. Polymer coated gate frames and gateposts: Match the coating type and color specified for the fence framework. Moveable parts such as hinges, latches and drop rods may be field coated in lieu of factory coated. Field Coating: Liquid polymer field touch up coating.

C. Round Steel Pipe and Rail: Schedule 40 ASTM F1083, Grade 1A, regular standard weight. 1.8 oz/sq ft hot-dipped galvanized zinc exterior and interior per ASTM A125.

D. Miscellaneous Hardware, Fittings and Appurtenances: Manufacture to industry standards, commercial quality, and suitable for the purpose used.

E. Terminal Posts, Rails, Brace assembly: see Caltrain Standard Drawing or Contract Drawing for details and dimensions.

F. Post Caps: Cast or malleable iron ball or acorn shape. Caps shall have opening for through rail where top rails are indicated.

G. Wire Ties shall be as follows:
   1. For tying fabric to tension wires: 11 gauge hog rings spaced 24 inches on center
   2. For tying fabric to line posts: 9 gauge wire spaced 12 inches on center
   3. For tying fabric to rails and braces: 9 gauge wire spaced 24 inches on center.
H. Bands: Use 14 gauge by 1 inch wide steel bands spaced 15 inches on center for securing stretcher bars to end, corner, pull and gate posts. Bands may be used in conjunction with special fittings for securing rails to end, corner and pull posts. Chamfer or ease projecting edges of bands.

I. Sleeves for Anchoring Railing Posts in Concrete: Galvanized standard pipe sleeves with welded on bottom plates, or 24 gage galvanized sheet metal sleeves with bottoms.

J. Galvanizing: Hot dip galvanize ferrous materials after fabrication per ASTM A125 or A153 as applicable. Repair zinc coating damaged in shop or during field erection by recoating with hot repair compound, applied per manufacturer’s recommendations.

K. Hot Repair Compound: Re Galv, Galvalloy, Galweld alloy, or Engineer approved equal.


M. Gates shall be swing type or sliding type as indicated in the Contract Drawings, furnished complete with all hardware and accessories as required for a complete installation.

1. Gate Frames: Frames shall be fabricated with materials as specified for fence framework and fabric.

2. Fabrication: Conform to applicable requirements of ASTM F900, Federal Specification RR-F-191/C, and the following:

   a. Assemble gate frames by welding or with fittings and rivets for rigid connections. Attach hardware with rivets or by other means that will provide security against removal or breakage.

   b. Provide additional horizontal members, vertical members, and diagonal cross bracing to ensure proper gate operation, frame rigidity without sag or twist, and for attachment of fabric, hardware, and accessories.

3. Gate Hardware:

   a. Swinging Gates: Provide gate hinges, latch, stop, and keeper for each gate leaf, conforming to applicable requirements of ASTM F900 and Federal Specification RR-F-191/2C. Provide latch with provision for locking gate with a padlock.

   b. Sliding Gates: Provide manufacturer’s standard rubber-tired rollers and roller track for floor-supported sliding gates. Include intermediate rollers or casters where required to prevent gate sag or deflection. Provide locking device and padlock eyes as part of latch for locking gate with a padlock.
2.02 CONCRETE

A. Concrete: Concrete shall conform to the following:

1. Portland Cement: ASTM C-150, type 2 or 5 (Low alkali)

2. Aggregates:
   a. Coarse aggregates: crushed rock, max 1-1/2 inch, #200: 2% maximum
   b. Sand: 3/8 inch maximum, #200: 2% maximum

3. Compressive strength (minimum): 2,500 psi @7 days, 4,000 psi @ 28 days

4. Slumps: 2 to 4.5 inches

B. Footing hole shall be clear of roots or other organic materials. Moist hole prior to concrete pour. No water standing at bottom of hole.

C. Consolidate concrete and remove air pockets.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Alignment and Grade: Verify horizontal alignment and grades as established by survey and plan dimensions and elevations. Securely set posts in alignment at proper depth and height, and rigid bracing where needed.

B. Concrete Footings: Drill or dig holes for post footings in firm, undisturbed or compacted soil. Depth and post embedment as indicated in the Caltrain Standard Drawing. Trowel tops of footings and slope or dome to direct water away from posts. Slope, do not dome, in pedestrian paving.

C. Setting Posts:

1. Set in concrete footings, plumbed vertical. Post depth and spacing as indicated on the Standard Drawing or Contract Drawing. Space posts at lesser distance between centers to compensate for terrain variation such as sharp variations in incline or decline.

2. Grout posts in concrete walls and curbs in sleeved holes with non-shrink grout. If built in without sleeves, set posts in vertical and top edge alignment, hold in place until concrete has set.

D. Fit posts with post caps, line post caps, or barbed wire extension arms, as applicable. Snugly fit fittings over posts and exclude moisture.

E. Top Rail: Pass top rails through the line post caps and form a continuous brace from end to end of each stretch of fence. Join top rail lengths with sleeves. Securely fasten top rail to terminal posts by means of rail ends and brace bands. Provide expansion couplers as recommended by the fence manufacturer.
F. Horizontal Braces and Truss Rods: Securely fasten brace to the line post and terminal post by rail ends and brace bands. Install a truss rod, including tightening device, from the end of the brace on the line post to the terminal post just above the bottom of fence fabric using brace bands.

G. Diagonal Braces: Install the diagonal brace with rail ends and brace bands. Fasten the brace at the locations described for a truss rod.

H. Tension Wire: Stretch tension wire out between terminal posts and secure at the terminal posts by means of tension bands.

I. Fence Fabric: Pull fabric taut and tie to posts, rails and tension wires. Fabric shall remain under tension after pulling force is released.

J. Tie Wires: Use U-shaped wires, same diameter as pipe to which attached, clamping pipe and fabric firmly with ends twisted two full turns minimum. Bend ends of wires to prevent hazard to persons or apparel.


L. Gates shall be installed plumb, level, and secure for full opening without interference. Install ground-set items in concrete as recommended by the fence manufacturer. Adjust hardware for smooth operation and lubricate. Sliding gates shall operate smoothly and easily under minimum pressure.

3.02 REPAIR

A. Repair abraded or damaged galvanized surfaces with hot process field galvanizing in accordance with ASTM A780 and manufacturer’s published instructions.

B. For polymer-coated panels, prepare and recoat damaged PVC coatings, including where component has been cut, in accordance with manufacturer’s instructions.

END OF SECTION
SECTION 02820
EXPANDED METAL MESH FENCE

PART 1 - GENERAL

1.01 DESCRIPTION

A. Section includes specifications for expanded metal mesh fence and gates (personal, and sliding or swing gates).

1.02 REFERENCE STANDARDS

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


3. A1011 Specification for Steel, Sheet and Strip, Hot-rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength

4. F626 Specification for Fence Fittings

5. F1083 Specification for Pipe, Steel, Hot-Dipped Zinc Coated (Galvanized) Welded, for Fence Structures

6. F1267 Specification for Metal, Expanded, Steel

1.03 SUBMITTALS

A. Submit shop drawings showing plan layout, grid, spacing of components, accessories, fittings and hardware.

B. Submit manufacturer’s product data.

C. Submit manufacturer’s installation instructions.

1.04 DELIVERABLES

A. Submit manufacturer’s certificates of compliance for fence materials.

B. Qualifications: Submit name, business address and telephone number of manufacturer’s field representative. Include certification by the manufacturer that proposed field representative is qualified to provide specified services.

C. Certification of Installation: Subject affidavit by the manufacturer’s field representative certifying that the installation of the expanded metal mesh fence meets the Contract requirements.
1.05 QUALITY ASSURANCE

A. Obtain the services of fencing manufacturer's field representative to provide the following services:
   1. Supervise the entire installation of the fence
   2. Render advice and assistance on the installation of the fence panels, posts, and fasteners

1.06 EXTRA MATERIALS

A. Extra materials shall match that installed in the Work. Furnish the following extra materials for every 1,000 linear feet (or fraction thereof) of each separate height and type of fence:
   1. Two panels, with required number of fittings for installation, including 2 line posts fitted with caps.
   2. Fittings (in addition to fittings furnished with extra panels): 20 - 2-1/2 inches clamps; 20 - 1 5/8 inch clamps; 20 – 2-1/2 inches line rail clamps; 20 back straps.

PART 2 - PRODUCTS

2.01 RIGHT-OF-WAY FENCE

A. Secura Expanded Mesh Fence System as manufactured by Alabama Metal Industries Corporation (AMICO), or Engineer approved equal.

B. Fabric: Type I (expanded), Class 2 (hot-dip galvanized), Grade A (0.06 mm minimum coating thickness) Carbon HSLA steel conforming to ASTM A1011. Sheet steel slit and stretched into a rigid, open mesh diamond shape openings.
   1. Maximum carbon content of 0.15 percent
   2. Tensile strength shall be at least 40,000 psi with typical yield point of 38,000 psi
   3. Mesh Strand (nominal minimum): 0.1 inch (width and thick)
   4. Short way of diamond run horizontally.

C. Terminal Posts: Posts shall comply with ASTM F1083, and the following:
   1. Mesh configuration, terminal posts, bracing, railings, etc.: see Caltrain Standard Drawing or Contract Drawing for details and dimensions.
   2. Terminal Posts (end, corner, gate, line posts): 4 inch nominal diameter, schedule 40 pipe. Each cap shall have a cap to seal out moisture.
   4. Post Cap: Pressed steel dome cap
   5. Base Plates and Miscellaneous Hardware: ASTM A36
D. Horizontal Rails: Rails shall comply with ASTM F1083. All rails shall be cut between and securely fastened to the posts using the proper sized 11 gage line rail clamps.

E. Fasteners and Fittings: Manufacturer fittings, and all hot-dip galvanized.
   1. Fittings: "No Access Fittings", heavy pressed steel construction conforming to ASTM F626
   2. Bands: Secura Bands: 11 gauge by 1 inch steel with 3 inch neck and slotted hole
   3. Clamps: Secura Clamps: 11 gauge by 1 inch steel with 2 slotted holes
   4. Back Straps: Secura Back Straps: 11 gauge by 1 inch steel with 2 slotted holes
   5. Bolts: Carriage bolts 3/8 inch by 2 inch to secure fittings. Tighten securely and peen or scarf threads to prevent removal.

F. Gate Hardware: Hinges, latches, drop rods, as needed, shall be hot dip galvanized steel and sized to assure proper gate operation. Finish to match the fabric.

2.02 CONCRETE

A. Concrete: Concrete shall conform to the following:
   1. Portland Cement: ASTM C-150, type 2 or 5 (Low alkali)
   2. Aggregates:
      a. Coarse aggregates: crushed rock, max 1-1/2 inch, #200: 2% maximum
      b. Sand: 3/8 inch maximum, #200: 2% maximum
   3. Compressive strength (minimum): 2,500 psi @7 days, 4,000 psi @ 28 days
   4. Slumps: 2 to 4.5 inches

B. Footing hole shall be clear of roots or other organic materials. Moist hole prior to concrete pour. No water standing at bottom of hole.

C. Consolidate concrete and remove air pockets.

2.03 SHOP FINISHES

A. Zinc: Hot dip galvanized posts and expanded metal mesh after fabrication in accordance with ASTM A123.
PART 3 - INSTALLATION

3.01 INSTALLATION

A. Alignment and Grade: Verify horizontal alignment and grades as established by survey and plan dimensions and elevations. Securely set posts in alignment at proper depth and height, and rigid bracing where needed.

B. Concrete Footings: Drill or dig holes for post footings in firm, undisturbed or compacted soil. Depth and post embedment as indicated in the Caltrain Standard Drawing. Trowel tops of footings and slope or dome to direct water away from posts. Slope, do not dome, in pedestrian paving.

C. Posts: Set in concrete footings, plumbed vertical. Post depth and spacing as indicated on the Standard Drawing or Contract Drawing. Space posts at lesser distance between centers to compensate for terrain variation such as sharp variations in incline or decline.

D. Fabric Panel to Post Attachment:

1. Attach panels to posts with bands sized to fit posts and spaced per manufacturer's recommendation.

2. To each terminal post, lap fence fabric over one half the width of the post to prevent any open space between the post and the fabric.

3. To each line post with the cant side of the fence fabric oriented in the same the same direction. Overlap fabric panels a minimum of three diamonds. Secure fabric panel to line posts using a minimum of seven (7) clamps, evenly spaced, per post with one above the top rail and one below the bottom rail.

4. Panels shall be placed within 2 inches of ground. High points which interfere with the placing of mesh panels shall be excavated to provide the clearance indicated on the Contract Drawings.

E. Fence Fabric: Pull fabric taut and tie to posts, rails and tension wires. Fabric shall remain under tension after pulling force is released.

F. Fabric to Horizontal Rail Attachment: Use a minimum of six (6) clamps per rail per panel. Evenly space clamps between posts.

G. Panel to Panel Attachment: Overlap fabric a minimum of 6 inches (three diamonds). Fasten using a minimum of six (6) back straps, evenly space, with one above the top rail and one below the top rail.

H. Gates shall be installed plumb, level, and secure for full opening without interference. Install ground-set items in concrete as recommended by the fence manufacturer. Adjust hardware for smooth operation and lubricate. Sliding gates shall operate smoothly and easily under minimum pressure.

3.02 REPAIR

A. Repair abraded or damaged galvanized surfaces with hot process field galvanizing in accordance with ASTM A780 and manufacturer’s published instructions.
END OF SECTION
SECTION 02830
WELDED WIRE MESH FENCE

PART 1 - GENERAL

1.01 DESCRIPTION

A. Section includes requirements for furnishing and installation of welded wire mesh fence and gates (personal, and swing or sliding gates). The Section includes furnishing extra materials.

1.02 REFERENCE STANDARDS

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

1. A36 Specification for Carbon Structural Steel
3. A500 Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
4. A501 Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing
5. F626 Standard Specification for Fence Fittings
6. F1083 Standard Specification for Pipe, Steel, Hot-Dipped Zinc Coated (Galvanized) Welded, for Fence Structures
7. D2201 Practice for Preparation of Zinc-Coated and Zinc-Alloy-Coated Steel Panels for Testing Paint and Related Coating Products

1.03 SUBMITTALS

A. Submit shop drawings showing plan layout, grid, spacing of components, accessories, fittings and hardware.
B. Submit manufacturer’s product data.
C. Submit manufacturer’s installation instructions.
D. Submit manufacturer’s color palette to the Engineer for approval.

1.04 DELIVERABLES

A. Submit manufacturer’s certificates of compliance for fence materials.
B. Qualifications: Submit name, business address and telephone number of manufacturer’s field representative. Include certification by the manufacturer that proposed field representative is qualified to provide specified services.
C. Certification of Installation: Subject affidavit by the manufacturer’s field representative certifying that the installation of the welded wire mesh fence meets the Contract requirements.

1.05 QUALITY ASSURANCE

A. Obtain the services of fencing manufacturer’s field representative to provide the following services:

1. Supervise the entire installation of the welded wire mesh fence.

2. Render advice and assistance on the installation of the welded wire mesh fence panels, fasteners and bracing; clip installation and fastening to post; and on tensioning of panels.

1.06 EXTRA MATERIALS

A. Extra materials shall match that installed in the Work. Furnish the following extra materials for every 1,000 linear feet (or fraction thereof) of each separate height and type of fence.

1. Two panels, including 2 line posts, including caps

2. Fittings (in addition to fittings furnished with extra panels): 20 each hat brackets; 20 each gouge ties; 20 each fasteners.

B. The panels shall be rolled and tightened with the posts; all hardware shall be in plastic or steel container(s) clearly marked “Fence and year of project”. Deliver these materials to the Engineer’s warehouse within 25 miles from project site.

PART 2 - PRODUCTS

2.01 RIGHT-OF-WAY FENCE

A. Typhoon style welded wire mesh fence system as manufactured by Secure Technology, or by CE Shepard, or Engineer approved equal.

B. Mesh configuration, terminal posts, bracing, railings, etc.: see Caltrain Standard Drawing or Contract Drawing.

C. Wire: Hardened elongated, 7 gage, stretched diameter.

1. The material breaking point of the welded mesh shall be at least 62,000 psi

2. The tensile strength of the wire mesh shall be at least 71,000 psi

3. The elongation factor of the wire mesh shall be 7 percent

4. Welding points shall be able to withstand force of at least 1200 lbs
D. Terminal Posts:
   1. The square steel tubing can be substituted with schedule 40 steel pipe only if the
      fence manufacturer has confirmed in writing that the tubular member is
      compatible to installation of the mesh fence panels.
   2. Post Caps: Each post shall have a square cap to seal out moisture. Flat and
      form plastic to the shape of the post. Coating to match the fabric.

E. Bottom Rails and Bracing:
   1. The rectangular steel tubing can be substituted with schedule 40 steel pipe
      only if the fence manufacturer has confirmed in writing that the tubular
      member is compatible to installation of the mesh fence panels.

F. Fence hardware: Manufacturer fittings, and all hot-dip galvanized.
   1. Fasteners Connecting Panels to Each Post: 3 mm diameter "U" shaped wire
      fastener.
   2. Hat brackets (horizontal connectors of the welded wire mesh fence): 0.05-
      inch thick by 1.18 inches long pre-molded clip fastener.
   3. Gouge ties (vertical connectors of the welded wire mesh fence): 0.05-inch
      thick by 0.59 inches long pre-molded clip fastener.

F. Gate Hardware: Hinges, latches, drop rods, as needed, shall be hot dip galvanized
   steel and sized to assure proper gate operation. Finish to match the fabric.

2.02 CONCRETE

A. Alignment and Grade: Verify horizontal alignment and grades as established by
   survey and plan dimensions and elevations. Securely set posts in alignment at
   proper depth and height, and rigid bracing where needed.

B. Concrete: Concrete shall conform to the following:
   1. Portland Cement: ASTM C-150, type 2 or 5 (Low alkali)
   2. Aggregates:
      a. coarse aggregates: crushed rock, max 1-1/2 inch, #200: 2% maximum
      b. Sand: 3/8 inch maximum, #200: 2% maximum
   3. Compressive strength (minimum): 2,500 psi @7 days, 4,000 psi @ 28 days
   4. Slumps: 2 to 4.5 inches

C. Footing hole shall be clear of roots or other organic materials. Moist hole prior to
   concrete pour. No water standing at bottom of hole.

D. Consolidate concrete and remove air pockets.
2.03 SHOP FINISHES

A. Zinc: Hot dip galvanized posts and welded wire mesh after fabrication in accordance with ASTM A123.

PART 3 - INSTALLATION

3.01 INSTALLATION

A. Concrete Footings: Drill or dig holes for post footings in firm, undisturbed or compacted soil. Depth and post embedment as indicated in the Caltrain Standard Drawing. Trowel tops of footings and slope or dome to direct water away from posts. Slope, do not dome, in pedestrian paving.

B. Posts: Set in concrete footings, plumbed vertical. Post depth and spacing as indicated on the Standard Drawing or Contract Drawing. Space posts at lesser distance between centers to compensate for terrain variation such as sharp variations in incline or decline.

C. Install welded mesh panels according to manufacturer’s instructions and generally as follows:

1. Begin at corner/start post. Layout each piece of the welded wire mesh fence. Connect mesh panels with a minimum of 8 junction clips per panel.

2. Connect one end of tensioning device to the intermediate post that is fastened to support brace. Connect other end of tensioning device to the connected panels. Tension mesh panels with 2000 lb. pull in tensioning device. Leave tensioning device connected until the adjacent section is installed and tensioned. Repeat this operation until the welded mesh fence is installed from corner post to corner post.

3. Trim panels as needed for landscaped purposes.

D. Fence Fabric: Pull fabric taut and tie to posts, rails and tension wires. Fabric shall remain under tension after pulling force is released.

E. Gates shall be installed plumb, level, and secure for full opening without interference. Install ground-set items in concrete as recommended by the fence manufacturer. Adjust hardware for smooth operation and lubricate. Sliding gates shall operate smoothly and easily under minimum pressure.

3.02 REPAIR

A. Repair abraded or damaged galvanized surfaces with hot process field galvanizing in accordance with ASTM A780 and manufacturer’s published instructions.

END OF SECTION
SECTION 02900
PLANTING

PART 1 – GENERAL

1.01 DESCRIPTION

A. Section includes requirements for landscaping, including furnishing and installing topsoil, soil amendments, mulch, trees, shrubs, groundcovers, tree staking, and header boards.

1.02 REFERENCE STANDARDS

A. American National Standards Institute (ANSI):
   1. Z60.1 American Standard for Nursery Stock

B. ASTM International (ASTM International):
   1. A641 Specification for Zinc-Coated (Galvanized) Carbon Steel Wire
   2. D5268 Specification for Topsoil Used for Landscaping Purposes

1.03 DEFINITIONS

A. Balled and Burlapped Stock: Exterior plants dug with firm, natural balls of earth in which they are grown, with ball size not less than sizes indicated. Stock shall be wrapped, tied, rigidly supported, and drum-laced conforming to the requirements in ANSI Z60.1.

B. Container-Grown Stock: Healthy, vigorous, well-rooted exterior plants grown in a container with well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1 for kind, type, and size of exterior plant required.

C. Finish Grade: Elevation of finished surface of planting soil.

D. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.

E. Subgrade: Surface or elevation of subsoil remaining after completing excavation or top surface of a fill or backfill before placing planting soil.

1.04 SUBMITTALS

A. Submit product data for each type of product.

B. Samples for verification for each of the following:
   1. One pound of bark mulch in labeled plastic bags
C. Submit certificates of compliance for each type of manufactured product, signed by product manufacturer, certifying the following:

1. Manufacturer's certified analysis for standard products

2. Analysis of other materials by a recognized laboratory conforming to methods established by the Association of Official Analytical Chemists, where applicable.

D. Material test reports for existing surface soil, imported topsoil, and soil amendments. Include laboratory reports for topsoil including analysis and recommendation.

E. Qualification data for landscape installer and soil-testing laboratory.

F. Maintenance instructions listing recommended procedures to be established by the Owner for maintenance of exterior plants during a calendar year; submit before expiration of required maintenance periods.

1.05 DELIVERABLES

A. Planting schedule indicating anticipated planting dates for exterior plants. Coordinate planting schedule with Progress Schedule.

1.06 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful establishment of exterior plants. Installer shall possess a State of California Landscape Contractor’s license and meet the State of California Licensing Requirements for the application of herbicides.

B. Installer’s Field Supervision: Installer shall maintain an experienced full-time supervisor on site when exterior planting is in progress.

C. Soil-Testing Laboratory Qualifications: An independent laboratory recognized by the State Department of Agriculture with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.

D. Pre-Installation Conference: Conduct pre-installation conference at project site. Schedule conference in coordination with the Engineer. Attendees shall include Contractor, planting installer, landscape irrigation installer, and the Engineer.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Deliver exterior plants freshly dug.

B. Do not prune trees and shrubs before delivery. Protect bark, branches, and root systems from sun scald, drying, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Provide protective covering of exterior plants during delivery. Do not drop exterior plants during delivery.

C. Handle planting stock by root ball.

D. Deliver exterior plants after preparations for planting have been completed and install immediately. If planting is delayed more than 6 hours after delivery, set
exterior plants and trees in shade, protect from weather and mechanical damage, and keep roots moist.

1. Do not remove container-grown stock from containers before time of planting.

2. Water root systems of exterior plants stored on-site with a fine-mist spray. Water as often as necessary to maintain root systems in a moist condition.

E. Store fertilizers and soil amendments in a dry place and protect from intrusion of moisture.

1.08 COORDINATION

A. Coordinate installation of planting materials during normal planting seasons for each type of plant material required.

B. Proceed with planting only when existing and forecasted weather conditions permit.

1.09 WARRANTY

A. Refer to General Provisions GP4.3, Guaranty of Work. The Guaranty of Work shall include the following provisions in regard to planting including plant materials.

1. Warrant against defects including death and unsatisfactory growth, except for defects resulting from lack of adequate maintenance, neglect, or abuse by Owner, or incidents that are beyond the Contractor’s control.

2. Remove dead exterior plants immediately, and replace immediately unless required to plant in the succeeding planting season.

3. Replace exterior plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.

4. A limit of one replacement of each exterior plant will be required, except when losses or replacements are due to failure to comply with requirements.

1.10 MAINTENANCE

A. Maintenance Period: 12 months from date of Substantial Completion.

B. Trees and Shrubs: Perform maintenance throughout the maintenance period including pruning, cultivating, watering, weeding, fertilizing, restoring planting saucers, tightening and repairing stakes and guy supports, and resetting to proper grades and vertical position as required to establish healthy, viable plantings. Spray as required to keep trees and shrubs free of insects and disease. Restore or replace damaged tree wrappings.

C. Ground Cover and Plants: Perform maintenance throughout the maintenance period including watering, weeding, fertilizing, and other operations as required to establish healthy, viable plantings:
PART 2 - PRODUCTS

2.01 GENERAL

A. Provide quality, size, genus, species and variety of exterior plants indicated conforming to the requirements in ANSI Z60.1.

B. Selection of exterior plants shall be made in conjunction with the Engineer, who will witness tagging plants at their place of growth before they are prepared for transplanting.

C. Measure trees and shrubs according to ANSI Z60.1 with branches and trunks or canes in their normal position. Do not prune to obtain required sizes. Take caliper measurements 6 inches above ground for trees up to 4-inch caliper size, and 12 inches above ground for larger sizes. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip-to-tip.

D. The Engineer may observe trees and shrubs either at place of growth or at site before planting for compliance with requirements for genus, species, variety, size, and quality. The Engineer retains the right to observe trees and shrubs further for size and condition of balls and root systems, insects, injuries and latent defects, and to reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from the project site.

1. Notify the Engineer of sources of planting materials 7 days in advance of delivery to site.

2. Make no plant substitutions.

2.02 TREE AND SHRUB MATERIAL

A. Furnish nursery-grown trees and shrubs conforming to the requirements in ANSI Z60.1 with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock free of disease, insects, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions and disfigurement.

B. Provide trees and shrubs of sizes and grades conforming to the requirements in ANSI Z60.1 for type of trees and shrubs required. Trees and shrubs of a larger size may be used if acceptable to the Engineer with a proportionate increase in size of roots or balls.

C. Label each tree and shrub with securely attached, waterproof tag bearing legible designation of botanical and common name.

D. If formal arrangements or consecutive order of trees or shrubs is shown, select stock for uniform height and spread, and number label to assure symmetry in planting.

2.03 SHADE AND FLOWERING TREES

A. Shade Trees: Single-stem trees with straight trunk, well-balanced crown and intact leader, of size indicated, conforming to the requirements in ANSI Z60.1 for type of trees required.

1. Branching height shall be 1/3 to 1/2 of tree height
2. Provide container-grown trees

B. Small Upright or Spreading Trees: Branched or pruned naturally according to species and type, with relationship of caliper, height and branching conforming to the requirements in ANSI Z60.1.

1. Stem form shall be multi-stem, clump, with 2 or more main stems
2. Provide container-grown trees

2.04 GROUND COVERS
A. Provide ground cover of species indicated, established and well-rooted in pots or similar containers, conforming to the requirements in ANSI Z60.1.

2.05 TOPSOIL
A. Topsoil shall conform to the requirements in ASTM D5268, pH range of 6.0 to 6.8, fertile, friable, natural topsoil of sandy loam character, without admixture of sub-soil material, obtained from a well drained arable site, reasonably free from clay, lumps, coarse sands, stones, plants, roots, sticks and other foreign materials.

1. Identify source location of topsoil proposed for use in the Work.
2. Provide topsoil free of substances harmful to the plants which will be grown in the soil.

B. Furnish topsoil analysis by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; deleterious material; pH; and mineral and plant-nutrient content of topsoil.

1. Include suitability of topsoil for plant growth. State recommended quantities of nitrogen, phosphorus, potash nutrients and soil amendments to be added to produce satisfactory topsoil.

2.06 ORGANIC SOIL AMENDMENTS

A. Compost: Well-composted, stable and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through one-inch sieve; soluble salt content of 5 to 10 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and the following:

1. Organic Matter Content: 50 to 60 percent of dry weight
2. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste

B. Peat: Sphagnum peat moss, partially decomposed, finely divided or granular texture, with a pH range of 3.4 to 4.8.

C. Wood Derivatives: Decomposed, nitrogen-treated sawdust, ground bark, or wood waste of uniform texture, free of chips, stones, sticks, soil or toxic materials.
1. In lieu of decomposed wood derivatives, mix partially decomposed wood derivatives with at least 0.15 lbs of ammonium nitrate or 0.25 lbs of...
ammonium sulfate per cubic foot of loose sawdust or ground bark.

D. Manure: Well-rotted, unleached, stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed and material harmful to plant growth.

2.07 FERTILIZER

A. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous and potassium in the following composition:

1. Nitrogen, phosphorous and potassium in amounts recommended in soil reports from a qualified soil-testing agency.

B. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus and potassium in the following composition:

1. Nitrogen, phosphorous and potassium in amounts recommended in topsoil analysis.

2.08 PLANTING SOIL

A. Planting Soil: Native or imported topsoil, manufactured topsoil, or surface soil modified to become topsoil; mixed with soil amendments.

2.09 MULCHES

A. Organic mulch shall be free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of one of the following:

1. Medium fir bark or wood chips
2. Rock mulch: As specified in the Contract Documents

2.10 STAKES

A. Metal Stakes for 15 gallon can and 24 inch box trees: Schedule 40 steel, 9-foot length, 3/4 inch diameter, with screw in auger-type tip, adjustable height 'T'-bar, UV-resistant vinyl tubing, 3 cable ties, anti-rotational tab and pin, powder coated black. As available from Decorations for Generations, Inc. Guy and Tie Wire: Conform to ASTM A641, Class 1, galvanized-steel wire, 2-strand, twisted, 0.106-inch in diameter.

2.11 MISCELLANEOUS PRODUCTS

A. Anti-desiccant: Water-insoluble emulsion, permeable moisture retarder, film forming for trees and shrubs. Deliver in original, sealed and fully labeled containers and mix according to manufacturer’s written instructions.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas to receive exterior plants for compliance with requirements and
conditions affecting installation and performance. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Protect structures, utilities, sidewalks, pavements and other facilities, and lawns and existing exterior plants from damage caused by planting operations.

B. Refer to Section 01560, Temporary Controls, for requirements to prevent erosion, displacement of soils, discharge of soil-bearing water runoff, and airborne dust.

C. Lay out individual tree and shrub locations, and areas for multiple plantings. Stake locations, outline areas, adjust locations when requested, and obtain acceptance of the layout by the Engineer before planting. Make adjustments as required.

D. Apply anti-desiccant to trees and shrubs using power spray to provide an adequate film over trunks, branches, stems, twigs and foliage to protect during digging, handling and transportation.

1. If deciduous trees or shrubs are moved in full leaf, spray with anti-desiccant at nursery before moving and again 2 weeks after planting.

3.03 PLANTING BED ESTABLISHMENT

A. Loosen subgrade of planting beds to a minimum depth of 8 inches. Remove stones larger than one inch in any dimension and sticks, roots, rubbish and other extraneous matter.

1. Apply superphosphate fertilizer directly to subgrade before loosening.

2. Spread topsoil, apply soil amendments and fertilizer on surface, and thoroughly blend planting soil mix.

   a. Delay mixing fertilizer with planting soil if planting will not proceed within a few days

   b. Mix lime with dry soil before mixing fertilizer

B. Topsoil Amendment, Topsoil Placement, and Fine Grading:

1. Place and spread topsoil to a minimum uniform thickness of 4 to 5 inches throughout areas designated to receive landscape planting, allowing for addition of amendments and plant materials, and mulch where indicated.

   a. Provide imported topsoil needed to fill remainder of site planting areas to finish grade.

2. Amend new topsoil according to the following: At each 1,000 square feet or per 20 cubic yards, spread 6 cubic yards soil amendment, 15 pounds commercial fertilizer, 10 pounds soil sulfur and 10 pounds iron sulfate evenly over topsoil at rates and depths indicated, then uniformly and thoroughly incorporate into the upper 6 inches of soil to obtain a homogeneous soil mix. Topsoil shall be in a moist condition at time of mixing.

   a. Amendment and fertilizer may be premixed prior to placement of
topsoil.

b. Modify quantities of soil sulfur, iron sulfate, and soil amendment in accordance with recommendations in topsoil analysis.

3. Deposit and spread topsoil using methods that will prevent excessive compaction of topsoil.

4. Provide a smooth finish grade by blading, dragging or other methods acceptable to the Engineer. Remove high spots and fill depressions. Place grades, slopes and mounds to drain as shown on the Contract Drawings.

   a. Finely finish surfaces by raking smoothly and evenly, removing all exposed, extraneous matter one inch or larger in size to facilitate natural runoff. Drag areas for smooth surface.

   b. Slope finish grades to drain without water pockets or irregularities (bumps or hollows). Finish grades shall meet all existing controls and shall be 3 inches below adjacent top of paving, curbs or sidewalks to allow for top dressing mulch or 5 inches below top of paving, curbs or sidewalks to allow for rock mulch. Grades shall be of uniform slope between points of fixed elevation. Establish vertical curves or roundings at abrupt changes in slope.

   c. Obtain the Engineer's review and approval of finish grades prior to commencing the planting operations.

C. Restore planting beds if eroded or otherwise disturbed after finish grading and before planting.

3.04 TREE AND SHRUB EXCAVATION

A. Excavate circular pits with sides sloped inward. Trim base leaving center area raised slightly to support root ball and assist in drainage. Do not further disturb base. Scarify sides of plant pit smeared or smoothed during excavation.

   1. Excavate approximately 3 times as wide as ball diameter for container-grown stock.

   2. Excavate at least 12 inches wider than root spread and deep enough to accommodate vertical roots for bare-root stock.

   3. If drain tile is shown or required under planted areas, excavate to top of porous backfill over tile.

B. Do not use subsoil removed from excavations as backfill. Use planting soil (see definitions).

C. Notify the Engineer if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations. Make adjustments to location of pit in consultation with the Engineer and excavate new pit.

D. Notify the Engineer if subsoil conditions evidence unexpected water seepage or retention in tree or shrub pits.

E. If hardpan layer is encountered, drill 6-inch diameter holes into free-draining strata
or to a depth of 10 feet, whichever is less, and backfill with free-draining material.

F. Fill excavations with water and allow to percolate away before positioning trees and shrubs.

3.05 TREE AND SHRUB PLANTING

A. Set container-grown stock plumb and in center of pit or trench with top of root ball one inch above adjacent finish grades.

1. Carefully remove root ball from container without damaging root ball or plant.

2. Place planting soil mix around root ball in layers, tamping to settle mix and eliminate voids and air pockets. When pit is approximately one-half backfilled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed. Water again after placing and tamping final layer of planting soil mix.

B. Apply 2 inches average thickness of organic mulch extending 12 inches beyond edge of planting pit or trench. Do not place mulch within 3 inches of trunks or stems.

3.06 TREE AND SHRUB PRUNING

A. Prune, thin and shape trees and shrubs according to standard horticultural practice.

B. Prune trees to retain required height and spread. Do not cut tree leaders; remove only injured or dead branches from flowering trees. Prune shrubs to retain natural character. Shrub sizes indicated are sizes after pruning.

3.07 STAKING

A. Upright Staking and Tying: Stake trees of 2 inches through 5 inches caliper. Stake trees of less than 2 inches.

B. General: Stake or guy trees immediately after planting. Make modifications to staking procedures as required to accommodate field conditions.

1. Allow 1 to 3 inches sway in trunk or branches; do not pull tight

C. Guying and Staking: Staking (metal): Stake trees according to tree stake manufacturer’s recommendations.

3.08 GROUND COVER AND PLANTING

A. Set out and space ground cover and plants as shown on the Contract Drawings. Place 12 inches apart if no other spacing is shown on the Contract Drawings.

B. Dig holes large enough to allow spreading of roots and backfill with planting soil.

C. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water.

D. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.
E. Protect plants from hot sun and wind. Remove protection if plants show evidence of recovery from transplanting shock.

3.09 PLANTING BED MULCHING

A. Mulch backfilled surfaces of planting beds and other areas indicated.

B. Organic Mulch: Apply 2 inches average thickness of organic mulch and finish level with adjacent finish grades. Do not place mulch against plant stems.

3.10 CLEANUP AND PROTECTION

A. During exterior planting, keep adjacent paving and construction clean, and work area in an orderly condition.

B. Protect exterior plants from damage due to landscape operations, operations by other contractors and trades, and any other adjacent work. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged exterior planting.

3.11 DISPOSAL

A. Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash and debris, dispose of it in accordance with GP7.16, Disposal of Material Outside the Work Site.

END OF SECTION
SECTION 02910
PLANTING IRRIGATION

PART 1 - GENERAL

1.01 DESCRIPTION

A. Section includes specifications for automatic irrigation system.

1.02 REFERENCE STANDARDS

A. ASTM International (ASTM International):


2. D1785 Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120

3. D2241 Specification for Poly Vinyl Chloride (PVC) Pressure-Rated Pipe (SDR Series)


5. D2466 Specification for Poly Vinyl Chloride (PVC) Plastic Pipe Fittings, Schedule 40

B. National Sanitation Foundation (NSF)

1.03 SUBMITTALS

A. Materials list: Submit materials list. Include manufacturer, model number and description of all materials and equipment. Include sealants, cements, lubricants and other proprietary items.

B. Shop drawings: Submit shop drawings for assemblies not detailed on the Contract Drawings. Include mounting details for rain shutoff.

C. As-Built Planting Irrigation Drawings: Submit as specified in Section 01720, Contract Record Documents. The following requirements are in addition to those specified in Section 01720, Contract Record Documents:

1. Show every change from Contract Drawings and Specifications and exact as-built locations, sizes and kinds of equipment.

2. Dimension from 2 permanent points of reference such as building corners, sidewalks, road intersections or monuments to the following items:

   a. Connection to water source
b. Valves (ball valves, remote control valves, quick coupling valves)

c. Routing of pressure lines

d. Controller

D. Operation and Maintenance Manuals: Submit as specified in Section 01730, Operations and Maintenance Manuals. Include the following data:

1. Copy of Controller Charts: Include full size and reduced versions of each chart as mounted in Controllers. Reduced versions shall be either 8 1/2 inches by 11 inches or 11 inches by 17 inches sheets, folded. Fold full size version and enclose in clear plastic pocket in manual binder.

1.04 QUALITY ASSURANCE

A. Installer of irrigation systems shall be a licensed Landscape Contractor.

1.05 DELIVERY, STORAGE AND HANDLING

A. Deliver piping with factory-applied end caps. Maintain end caps through shipping, storage and handling to prevent pipe-end damage and to prevent entrance of dirt, debris, and moisture.

B. Store plastic piping protected from direct sunlight. Support piping to prevent sagging and bending.

1.06 SEQUENCING AND SCHEDULING

A. Coordinate sprinkler piping with planting work specified in Section 02900, Planting.

B. Coordinate sprinkler piping with grading and utility work.

1.07 WARRANTY

A. Refer to General Provisions GP4.3, Guaranty of Work. The Guaranty of Work shall include the following provisions in regard to planting irrigation system:

1. Agree to repair or replace defective Work including adjacent work which is damaged by such defects, with the exception of ordinary wear and tear, abuse or neglect. This includes damage to site improvements caused by settlement of improperly compacted trench backfill.

1.08 MAINTENANCE MATERIALS

A. Special tools: Deliver two sets of special tools as required to operate, adjust, dismantle or repair equipment. Include tools not normally found in possession of maintenance personnel. At minimum provide the following:
1. Two sets of special tools and valve keys required for operating, removing, disassembling and adjusting each type of valve supplied on the Project.

2. Two quick coupler keys and matching hose swivels.

1.09 MAINTENANCE SERVICE

A. Maintain irrigation system in working order from beginning of work until the end of the Maintenance Period specified in Section 02900, Planting. Maintenance of system includes, for example, the following work: Flushing system and adjusting heads; providing optimum amounts of water to plants; replacing lost, stolen or damaged equipment; reprogramming controller.

1. In addition to hand watering required in Section 02900, Planting, for plant establishment. During any times when irrigation is not available due to maintenance of irrigation system, hand water as required for maintaining plants.

PART 2 - PRODUCTS

2.01 PVC PIPE AND FITTINGS

A. Polyvinyl Chloride (PVC) Pipe: NSF approved, Type 1, Grade 1 PVC compound; ASTM D1784, ASTM D1785 and ASTM D2241.

B. Pipe shall bear the following markings:

1. Manufacturer’s name
2. Nominal pipe size
3. Schedule or class
4. Pressure rating in PSI
5. Date of extrusion

C. Pressure Main Line Pipe: PVC 1120 plastic pipe: Class 315 for 1 1/2 inch and larger; schedule 40 for 1 1/4 inch and smaller.


E. Sleeves (Twice the diameter of working pipe):

1. Water lines: Schedule 40 PVC 1120
2. Electrical lines: Gray, schedule 40 PVC conduit
3. Caps: Schedule 40 PVC
F. Fittings:

1. Solvent weld socket fittings: Schedule 40, Type 1, Grade 1, NSF approved, ASTM D2466. Schedule 80, ASTM D2464. Fittings shall bear manufacturer's name or trademark, material designation, size, applicable IPS schedule and NSF seal of approval.

2. Solvent cement and primer for PVC solvent-weld pipe and fittings shall be of type and installation methods recommended by pipe manufacturer.

G. Risers: Schedule 80 PVC threaded nipples and elbows.

2.02 OTHER PIPING MATERIALS

A. Pipe upstream of (backflow preventer/master valve): Schedule 40 galvanized steel.

B. Pipe Wrapping Tape:

1. Metal pipe: 2-inch wide, 20 mils thick, black PVC, all weather corrosion-resistant tape with high tack adhesive formulated to resist corrosion. Use same manufacturer's pipe primer to seal pipe and prepare for tape wrapping.

2. PVC pipe: As above, except primer is not required.

C. Pipe Joint Compound: Non-hardening, non-toxic, designed specifically for use on PVC and metal threaded connections in water carrying pipe and as recommended by pipe manufacturer.

D. Flexible Riser/Connector: EPDM rubber hose, PVC ends, with stainless steel bands. Product specifically marketed for irrigation systems such as Flex-Riser, King Brothers Industries, or Engineer approved equal.

E. Provide dielectric fittings where dissimilar metals come into contact.

F. PVC Sleeves: Schedule 40 PVC.

G. Galvanized Steel Sleeve: ASTM A53

2.03 VALVES

A. Ball valve: Brass construction, stainless steel ball, two-piece body, threaded connections, with teflon seats and full port.

B. Plastic electric remote control valve:

1. Heavy-duty, stainless steel fasteners, nylon-reinforced rubber diaphragm

2. Normally closed with manual internal bleed; self-flushing stainless steel screen and brass flow control stem
3. Rated to 150 psi
4. 24 Vac solenoid actuated

C. Quick coupling valves: Bronze construction, 1 inch connection, two-piece body, yellow vinyl locking top, single slot and lug. Size: As indicated on the Contract Drawings.

D. Inline Wye Filter
1. Specifically for low flow applications
2. Rated to 150 psi
3. Standard 200 mesh screen
4. Shall not exceed 5 inches high, 6 inches long, and 2 1/2 inches wide

E. Inline Pressure Regulator: Rated not less than 80 psi.

2.04 VALVE BOXES

A. High Density Polyethylene (HDPE), green, UV resistant, with stainless steel bolt-down mechanism and heat-branded letters, minimum 2 inch height.
2. Quick coupling valve (QCV): Round, 10 inch diameter, series 910. Letters: "QCV".

2.05 SPRINKLER HEADS

A. Spray Sprinkler:
1. Matched precipitation rate, seamless molded plastic, with stainless steel adjustment screw and retraction spring.
2. Pressure activated wiper seal and removable flushing plug.
3. Pop-up body shall have pressure regulator for 30 psi pressure regulation to nozzle and integral check valve capable of preventing low-head drainage up to 8 feet of head.
4. Pop-up height: 6 inches in shrub and groundcover areas.
5. Nozzle: As shown on the Contract Drawings. Provide pressure compensating screen where required to reduce radius.

2.06 SUBSURFACE DRIP SYSTEM EQUIPMENT

A. Provide all components required for complete system to suit field conditions. All components shall be of single manufacturer.
1. Pressure regulator: Plastic, in-line serviceable, with built-in gauge, rated for 2.0 to 20 gpm.


3. Air relief valve: Plastic, 1/2 inch MPT

4. Tubing: Low density 5/8 inch polyethylene with Rootguard; 0.71 O.D.; 0.62 I.D. Shall have integral, pressure compensating, self-cleaning emitters, 12 inches on center. Emitter flow: 1.02 gph. Shall maintain constant flow at inlet pressure of 5 to 50 psi. Provide fittings, staples adapters and other components of same manufacturer.

5. Line flushing valve: Plastic, 1 gpm, 1/2 inch MPT inlet, shall flush automatically at start of each cycle.

6. Stainless steel clamp: Type 304 stainless steel, screwed hose clamps, as recommended by manufacturer of subsurface irrigation system.

7. Emitter – Multi-Outlet Device – 8 Port, with 1/2 inch inlet

2.07 BACKFLOW PREVENTION DEVICE

A. Reduced pressure type, bronze with 304 stainless steel springs, with two (2) ball valves, pressure rated to 175 psi, 1-inch size.

2.08 CONTROLLER

A. UL listing; pedestal mount, as shown on the Contract Drawings. Controllers shall be factory mounted in manufacturer’s enclosure unless otherwise shown.

B. Solid state, microprocessor-based, capable of fully-automatic, semi-automatic or manual operation.

C. Programming: 24 Station. Station timing: 1 minute to 99 minutes in 1 minute increments. Non-volatile memory.

D. Master valve/pump start circuit and valve test function

E. Water budgeting: 0 - 200 percent

F. 6 starts per program per day

G. Standby watering schedule

H. Rainbird, ESP-LX Series with locking steel cabinet, or Engineer approved equal

I. Controller charts: Provide controller charts the maximum size that the controller door will allow, showing areas covered by each controller. Color code area of coverage of each valve and enlarge valve sequence to be readable when
drawing is reduced. Reduce approved As-Built drawings and seal between two 20-mil plastic sheets; install inside door.

2.09 FLOW SENSOR
A. Schedule 80 PVC with removable, non-magnetic sensing mechanism. Rated to 100 psi at 140 degrees F.
B. Sensing mechanism: Electronic detector, glass reinforced polyphenylene sulfide housing with glass reinforced nylon impeller, UHMWPE bearing, tungsten carbide shaft, and EPDM O-rings.

2.10 CONTROL WIRE
A. Control wire: Soft-annealed, uncoated copper, single conductor, with PVC insulating jacket, UL approved for direct burial, size and color as follows:
   1. Common ground: White, size #12 AWG-UF
   2. Control wire: Color other than white, size #14-1 AWG-UF
B. Provide separate common ground for each controller.
C. Connections: Gel-sealed waterproof connector kit, UL listed for direct burial splices, with spring connector, vinyl insulator and moisture proof snap top packet. DBY/DBR connector sealing packs, as manufactured by 3M Company, Austin, TX, or equal.

2.11 RAIN SENSOR
A. Rain Sensor: Hygroscopic disks housed in UV stabilized, thermoplastic housing with weatherproof switch mechanism and 6 inch aluminum mounting bracket, with automatic return to normal watering cycle, as manufactured by Glen Hilton, Products, Inc, Richmond, VA, or equal.
B. Click stop settings shall measure rainfall in quantities of 1/8 to 1 inch and shut off watering cycle during rain. Set device to shut off system when rainfall reaches 1/2 inch.
C. Shall be low voltage, UL listed, with 25 feet of No. 20 AWG 2 conductor wire and lead wire for normally open wiring. Provide additional mounting hardware and wiring to suit project conditions.

2.12 TRENCH BACKFILL
A. Trench backfill in planting areas shall be planting mix specified in Section 02900, Planting.
B. Trench backfill under paving shall meet requirements of Section 02300, Earthwork.
2.13 OTHER MATERIALS

A. Concrete: As specified in Section 03300, Cast-in-Place Concrete. Minimum compressive strength: 3,000 psi.

B. Drain rock: 3/4 inch washed drain rock.

PART 3 - EXECUTION

3.01 COORDINATION

A. Protect existing and new above and below ground features.

B. Coordinate placement of items to be embedded into concrete work or installed under paving.

C. Design pressure is as shown on Contract Drawings. Verify static pressure at point of connection (POC) before starting construction and notify the Engineer if it is different from the design pressure.

D. Irrigation demand is shown on the Contract Drawings. Verify at POC before starting construction.

3.02 LAYOUT

A. Drawings: For purposes of clarity and legibility, the Contract Drawings are diagrammatic to the extent that many offsets, bends, unions, special fittings, and exact locations of items are not indicated, unless specifically dimensioned. Exact routing of piping, conduits and wiring shall be governed by actual site conditions.

1. Provide necessary fittings and offsets to adapt to existing conditions and prevent conflicts with other work and existing improvements.

B. Before installation, stake layout of pressure supply lines and valves for review. Coordinate with staked layout of trees provided under Section 02900, Planting. Adjust as required to ensure coverage, to avoid interference with planting.

3.03 BACKFILLING

A. Backfill with specified material after testing pipe. Compact backfill to a density equal to adjacent soil, or as specified in Section 02300, Earthwork.

B. Correct subsequent settlement of trenches, and correct any damage caused by settlement.

3.04 SLEEVES AND CONDUITS

A. Provide sleeves and conduit of sufficient size and quantity to accommodate all pipe and wiring. Install sleeves where control wires and pipe pass through or under walls and under paving. Provide galvanized steel pipe sleeves where sleeves are installed by jacking or boring.
B. Install minimum 7 inches below bottom of pavement base, and at least as deep as required depth of pipe.

C. Sleeves and caps: Extend minimum 12 inches beyond edge of pavement. In-line fittings are not permitted in sleeves less than 20 feet long. Cap ends of sleeves hand tight until pipe is installed.

1. Install sleeves and conduit level and in a straight line.

D. Backfill with 4 inches clean sand on all sides of sleeves, and compact by tamping.

E. Mark locations of sleeve ends with 2 x 4 stake extending 6 inches above finish grade, for future location during construction. Label stake clearly with letter "I". Remove stake when assembly is completed.

3.05 POINT OF CONNECTION/WATER METER

A. Make arrangements and pay costs for installation of water meters at locations indicated on Contract Documents. Coordinate with the jurisdictional authorities and the Engineer.

3.06 BACKFLOW PREVENTION DEVICE

A. Connect backflow prevention device to water supply line in approximate location shown on Contract Drawings.

B. Arrange and pay for tests and certificates required by jurisdictional authorities.

3.07 PIPE

A. General:

1. Install pipe under existing paving by jacking or boring.

2. Do not use pipe joint compound on sprinkler bases or remote control valves.

3. Cap open pipe ends as pipe line is assembled to keep out soil or debris. Remove caps only when necessary to continue assembly.

4. Sleeve pipe under paving. Where pipes or control wires pass through sleeves, provide removable non-decaying plug at ends of sleeves to keep soil out.

5. Pipe wrapping: Wrap galvanized pipe and fittings in contact with soil and to 3 inches above soil line. Overlap tape 1/2 its width.

6. Provide check valve where required to prevent erosion from low head drainage.
B. Solvent-weld PVC:

1. Install plastic pipe as recommended by manufacturer, including accommodating expansion and contraction.

2. Install PVC pipe in trench with manufacturer's markings facing up.

3. Cut pipe ends square and remove burrs. Pipe and fitting shall be free of dirt, dust and moisture.

4. Dry-insert pipe into fitting to check fit. Pipe should enter fitting 1/3 to 2/3 depth of socket.

5. Apply primer to socket and pipe end. Apply heavy coat of cement to pipe end. Apply light coat of cement to inside of socket and second coat to pipe end.

6. Insert pipe into fitting and turn 1/4 turn until pipe seats to the bottom of the socket. Check alignment of pipe and fitting.

7. Hold joint still for 30 seconds and remove excess cement.

8. Cure joint minimum 30 minutes before handling and 6 hours before filling with water.

C. Threaded joints:

1. Field threading of plastic pipe or fittings is not permitted. Use factory-made threads only.

2. Use factory-made metal nipples wherever possible. Field cut threads in metal pipe may be used only where approved by the Engineer. Cut threads accurately on axis with sharp dies.

3. Apply pipe joint compound to male threads and first 3 female threads.

4. On metal to metal joints, no more than 3 full threads shall show when joint is complete.

5. When assembling threaded plastic fittings, tighten joint no more than one (1) full turn beyond hand tight. Use strap type friction wrench only; do not use metal-jawed wrench.

3.08 VALVES

A. General:

1. After pipe and risers are in place and connected and before installation of valves, flush out system with a full head of water. Lines shall be free of soil or debris.

2. Locate and install as shown. Obtain Engineer's approval of location of valves and alignment of boxes.
B. Valve Box Installation, General:

1. Install boxes 18 inches from walk or header and 12 inches apart. Short side of rectangular boxes shall be parallel to walk or header. Install boxes 2 inches above finish grade in groundcover areas; flush in lawn areas.

2. Install common bricks as shown and as required to keep box stable. Place 3/4 inch drain rock inside box for drainage as shown.

3. No soil or accumulated water is permitted in valve boxes. Install PVC tape over box side cutouts.

C. Remote Control Valve:

1. Install where shown on Contract Drawings; group boxes together and install in groundcover areas wherever possible.

2. Install separate box for each valve.

3. Provide a separate riser and connection to mainline for each remote control valve shall have. Do not manifold valves to a single riser from mainline unless shown on the Contract Drawings.

4. Number valves in sequence shown on the Contract Drawings.

5. Label each valve with controller and station number on 2-1/4 inches by 2-3/4 inches polyurethane tag attached to control wire.

D. Quick coupling valve: Set valve perpendicular to finish grade, unless otherwise shown.

3.09 SPRINKLERS

A. Thoroughly flush lines before installing sprinkler heads.

B. Locate and install heads, risers and fittings as shown. Notify the Engineer and adjust layout and provide additional heads, as required, where field conditions or obstructions prevent adequate coverage.

C. Set heads perpendicular to finish grade, unless otherwise shown.

D. Adjust sprinkler heads for proper distribution and trim, providing complete coverage with minimal overspray.

3.10 CONTROLLER

A. Refer to the Sections of Division 16, Electrical, for specifications for power to the controller.
B. Install in approximate location shown on the Contract Drawings. Obtain Engineer’s acceptance of exact location. Connect to disconnect switch.

C. Mount enclosure as shown.

D. Connect control wires to controller according to valve numbers shown, in sequence shown on the Contract Drawings. Label each control wire with permanent label showing station number of valve controlled.

E. Rain sensor: Mount in location accepted by the Engineer, as shown on approved shop drawings. Connect according to manufacturer's instructions and wiring diagrams.

F. Control wire:
   1. Run lines along mains wherever possible. Provide separate conduit for wires under paving. Tie wires in bundles with 1-inch wide electrical tape at 10-foot intervals and allow slack for contraction between strapping. Tape is not required in sleeves.
   2. Loop three (3) feet of extra control and ground wires in 1-inch diameter coil, at each valve, at 100 foot intervals along wire runs, and at changes of direction.
   3. Splicing is not permitted.
   4. Install spare control wire of different color for each controller along entire main line.

G. Programming: Perform programming throughout construction and maintenance period. Provide optimum amounts of water for each plant type to maintain plants in vigorous healthy condition. Reprogram as required at end of maintenance period.

3.11 TESTING PIPE

A. Center-load pipe with approved backfill to anchor pipe before testing. Do not cover fittings.

B. Before testing, bleed air out of lines at line pressure. Provide vertical pipe at high points during installation.

C. Do not cover or enclose work until tests are approved by the Engineer.

D. Solvent weld pipe: Test hydrostatically after joints have cured at least 24 hours. Provide caps, pumps, pressure gauges and other equipment required to perform test.
   1. Test pressure mainline at 150 psi for 4 hours and prove watertight.
   2. Cap sprinkler risers and test lateral lines at line pressure. Review system for leaks.
E. Repair leaks and repeat tests until system is proven watertight.

F. Remake faulty joints with new materials. Do not use cement or caulking to seal leaks. Perform repairs in conformance with the Contract Documents.

3.12 DRIP SYSTEM POST-INSTALLATION CHECK

A. Immediately after installation, flush lateral line piping by removing the last emitter from each line.

B. Clean filter screens. Open filter flush valve for at least 10 seconds. Clean or replace clogged elements.

C. Operation check: While system is operating, check pressure gauge downstream from filter. Pressure shall be minimum 80 percent of supply pressure and minimum 10 percent above the setting of the pressure regulator.

D. Clean or replace filter element as required to obtain specified pressure.

E. Adjust pressure regulator to system design pressure.

F. Verify that emitters are producing specified water output. If not, replace emitters, check filter element, check pressure at emitters, and review system for clogs and leaks. Correct deficiencies.

3.13 FIELD QUALITY CONTROL

A. Progress observations: In addition to the observations specified below, the Engineer will make periodic progress observations.

B. Notify the Engineer in advance of the following observation meetings, as indicated:

1. Field layout: 3 days
2. Pressure supply line installation and testing: 48 hours
3. Controller installation: 48 hours
4. Coverage test: 48 hours
5. Maintenance period observations: 7 days
6. Final observation: 7 days

3.14 SYSTEM ADJUSTMENT

A. Flush and adjust sprinkler heads for optimum performance. Prevent overspray onto walks, roadways, paving and buildings. Adjust nozzle sizes and degree of arc, and install pressure compensating screens, as required to cover planting areas without overspray. Adjust valve flow controls.
B. Test and adjust entire system at completion of each phase or section of work.

C. Perform coverage test in the presence of the Engineer to establish that coverage of all planting areas is complete and adequate. Correct deficiencies and repeat test until approved by the Engineer.

3.15 ACCEPTANCE

A. Obtain Engineer’s acceptance of irrigation system after irrigation work is complete and after acceptance of planting work as specified in Section 02900, Planting.

B. Operate system during observation by the Engineer.

3.16 OPERATION INSTRUCTION

A. Refer to Section 01730, Operations and Maintenance Manuals. Provide six (6) hours instruction in operation and maintenance of system to Owner’s maintenance personnel, after completion and acceptance of irrigation system by the Engineer. Provide instruction by manufacturer’s representative where Contractor is not expert in operation of equipment.

END OF SECTION
SECTION 03100
CONCRETE FORMING

PART 1 - GENERAL

1.01 DESCRIPTION
A. Section includes specifications for design, construction, and removal of formwork for the placement of cast-in-place concrete.

1.02 REFERENCE STANDARDS
A. American Concrete Institute (ACI):
   1. 301 Specifications for Structural Concrete for Buildings
   2. 347 Guide to Formwork for Concrete
B. American Plywood Association (APA)
   1. PS1-95 U.S. Product Standard for Construction and Industrial Plywood
C. American Railway Engineering and Maintenance-of-Way Association (AREMA):
D. State of California, Department of Transportation, Standard Specifications, (Caltrans):
   1. Section 51, Concrete Structures

1.03 SYSTEM DESCRIPTION
A. The work of this Section shall be performed in accordance with the following provisions:
   1. AREMA Manual, Section 1.8, "Forms," of Section 8, "Concrete Structures and Foundations"
   2. Caltrans Standard Specifications, Section 51-1.05, "Forms"
   3. ACI 347

1.04 SUBMITTALS
A. Formwork Shop Drawings: Submit drawings that indicate the following:
   1. Forming system and method of erection with associated details, including bracing as required to ensure stability of formwork.
   2. Design calculations for the forming system.
3. Concrete placement rates and ambient temperature requirements at time of concrete placement.

4. Locations of all joints in concrete, including construction joints, expansion joints, isolation joints, cold joints, and contraction joints, in plan and elevation views.

5. Locations and sizes of inserts, embedments, conduits, openings, recesses, chamfers, reveals, rustications, blockouts, pipes, ducts and other attached products.

6. Form tie locations and patterns at exposed cast-in-place concrete.

7. Beam intersections and other conditions where concrete casting by vertical drop may be restricted.

8. Method and schedule for removing forms and shoring.


10. Coordinate with the requirements specified in Section 03300, Cast-In-Place Concrete.

B. Product Data: Provide manufacturers’ data and installation requirements on form materials, form coatings, form ties, and other accessories.

C. Samples: Submit form material with submittal of shop drawings, 12 inches by 12 inches or larger in size, for formed concrete which will be exposed in the finished work to the public view.

1.05 QUALITY ASSURANCE

A. The design of the formwork will be done under the supervision of a civil engineer registered in the State of California.

PART 2 - PRODUCTS

2.01 WOOD FORM MATERIALS

A. Provide form materials in accordance with the requirements of APA PS-1, including the following products:


2. B-C Plyform: Class I, EXT-APA, APA trade marked.


4. Thickness: As required to maintain surface smoothness without deflection, but not thinner than 5/8 inch.
B Lumber:

1. Boards: Use dressed side of lumber for surface in contact with the concrete and use dressed or tongue-and-groove edges.

2. Framing Lumber: Structural grade, dressed or rough.

2.02 PREFABRICATED FORMS

A. Preformed Steel Forms: At Contractor’s option, preformed steel forms may be used. Forms shall be structurally adequate, matched, tight fitting, stiffened to support weight of concrete without deflection detrimental to tolerances and appearance of finished surfaces. Provide surfaces which will not impart corrosion residue to concrete.

2.03 FORMWORK ACCESSORIES

A. Plugged Cone Form Ties: Rod type, with ends or end fastener which can be removed without spalling the concrete and which leave a hole equal in depth to the required reinforcement clearance. Form ties shall be of a design in which the hole left by the removed end or end fastener is easily filled to match the surface of the hardened concrete. Provide removable cones 1-1/4 inches in diameter by 1-1/2 inches deep.

B. Form Release Agent: Commercial formulation, silicone-free form-release agent, designed for use on all types of forms, which will not bond with, stain, nor adversely affect concrete surfaces, and which will not impair subsequent treatment of concrete surfaces requiring bond or adhesion nor impede wetting of surfaces which will be cured with water, steam, or curing compounds. Form release agent for use on steel forms shall be non-staining and rust-preventive.

C. Chamfer Strips: 3/4 inch by 3/4 inch triangular fillets milled from clear, straight-grain pine, surfaced each side or extruded vinyl type with or without nailing flange.

D. Miscellaneous Joint Strips: Preformed strips for reveals, rustication and similar joints fabricated of wood, metal, or plastic.

E. Dovetail Anchor Slot: Galvanized steel, 22 gage thick, release tape sealed slots, anchors for securing to concrete formwork.

F. Nails, Spikes, Lag Bolts, Through Bolts, Anchorages: Sized as required, of sufficient strength and character to maintain formwork in place during concrete placement.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify locations, lines, and levels before proceeding with formwork. Ensure that dimensions agree with shop drawings.
3.02   EARTH FORMS

A.  Hand trim sides and bottom of earth forms. Establish and maintain necessary benchmarks, lines, or controls throughout construction. Remove loose soil prior to placing concrete.

3.03   INSTALLATION

A.  Erect formwork, shoring and bracing to achieve design requirements and to maintain allowable tolerances in accordance with the requirements of ACI 301.

B.  Formwork of foundations shall not interfere with underground utilities, such as fiber optic cables, and railroad track operational clearances.

C.  Provide bracing to ensure stability of formwork. Shore or strengthen formwork subject to over-stressing by construction loads.

D.  Arrange and assemble formwork to permit dismantling and stripping. Do not damage concrete during stripping, and permit removal of remaining principal shores.

E.  Kerf wood inserts for forming keyways, reglets, and recesses in a manner that will prevent swelling and ensure ease of removal.

F.  Align joints and make watertight. Keep form joints to a minimum.

G.  Support joints with extra studs or girts and in a manner that will ensure true, square intersections.

H.  Provide chamfer strips on external corners of all concrete pours. Accurately shape and surface chamfer strips in a manner which will produce uniformly straight lines and edge joints and which will prevent mortar runs. Extend terminal edges to limits, and miter chamfer strips at changes in direction.

I.  Construct molding shapes, recesses and projections with smooth finish materials and install in forms with sealed joints.

J.  Provide camber in formwork as required to compensate for deflections caused by weight and pressures of fresh concrete and construction loads.

K.  Provide construction openings in forms where required for concrete pour pockets, vibrator access holes and inspection openings to aid in proper placement and consolidation of concrete and close up openings during placement of concrete as applicable.

L.  Provide inspection and cleanout openings in forms at bottom of walls and columns and elsewhere as required. Do not close cleanouts until inspected and accepted just before placing concrete.

M.  Drill air escape holes in bottom members of blockouts.

N.  Ensure that formed stair risers within stair run are equal.
O. Edge Forms and Screeds for Slabs: Set edge forms or bulkheads and intermediate screeds for slabs to obtain required elevations and contours in the finished slab surface. Support screeds substantially without penetrating waterproof membranes and vapor barriers.

P. Construction Joints:

1. Locate joints as indicated. Support forms for joints in concrete so as to rigidly maintain their positions during placement, vibration, and curing of concrete. Install keys in all joints.

2. Locate and install construction joints, for which locations are not indicated, so as not to impair strength and appearance of the structure and in accordance with approved Shop Drawings.

3. Position joints perpendicular to longitudinal axis of pier, beam, or slab as the case may be.

4. Locate joints in walls, vertically as indicated; at top of footing; at top of slabs on grade; at bottom of door openings; and at underside of the deepest beam or girder framing into wall; or as required to conform to indicated details.

5. Provide keyways as indicated in construction joints in walls and slabs, and between walls and footings, unless otherwise indicated. Place construction joints perpendicular to the main reinforcement. Continue reinforcement across construction joints.

Q. Load Supports: Loads for construction of roof slab and suspended floor slabs shall be carried down to on-grade base slabs. These loads shall not be carried by intermediate slabs at any time. Formwork loads shall be carried only by structural elements which are supported directly by footings.

3.04 FORM RELEASE AGENT

A. Apply form release agent on formwork in accordance with manufacturer's recommendations, prior to placement of reinforcing steel, anchoring devices, and embedded items. Do not allow excess form release agent material to accumulate in the forms or to come into contact with surfaces which are required to be bonded to fresh concrete such as concrete reinforcement and embedded items.

B. Protect steel forms from rust with form release agent or otherwise protect against rusting.

C. Apply release agent to bolts and rods that are to be removed or that are to be free to move.

3.05 INSERTS, EMBEDDED PARTS, AND OPENINGS

A. Provide formed openings for items to be embedded in or passing through
formwork.

B. Locate and set in place items that will be cast directly into concrete.

C. Coordinate with related work of other Sections in forming and placing openings, slots, recesses, chases, sleeves, bolts, anchors, ties, inserts, and similar embedded items.

D. Install accessories in accordance with manufacturer's instructions, straight, level, and plumb. Secure items to prevent disturbance during concrete placement.

E. Provide temporary ports or openings in formwork to facilitate cleaning and inspection. Locate openings at bottom of forms to allow flushing water to drain.

F. Close temporary openings with tight fitting panels, flush with inside face of forms, and neatly fitted so joints will not be apparent in exposed concrete surfaces.

3.06 FORM CLEANING

A. Clean and remove foreign matter within forms as erection of formwork proceeds.

B. Clean debris from formed cavities prior to placing concrete.

C. Flush with water or use compressed air to remove remaining foreign matter. Ensure that water and debris drain to exterior through clean-out ports.

3.07 FORM STRIPPING

A. Do not remove forms or bracing until concrete members have sufficient strength to safely support their own weight and all superimposed loads.

B. Leave forms in place for at least 3 days, unless results of tests show that 70 percent of specified strength has been achieved. At times of low temperature or other adverse weather conditions, increase the required time to 5 days.

C. Do not remove or release falsework and forms supporting concrete girders, beams, joists, slabs, walls, or other members subject to bending stress in less than 14 days after the concrete has been placed. In any case, do not remove falsework and forms supporting the members until the concrete has attained at least 70 percent of the indicated design compressive strength on test results of laboratory cured cylinders. Do not load such members until the concrete has attained its 28-day compressive strength.

D. Loosen forms carefully, and remove without hammering or prying against finished concrete surfaces.

E. Protect concrete surface from damage. Store removed forms for re-use, as appropriate, and remove damaged forms from the site and dispose of.

F. As soon as the forms have been stripped and the concrete surfaces exposed, commence finishing and repairs such as removal of fins and other projections,
filling recesses left by the removal of form ties, and repair surface defects as specified in Section 03170, Concrete Finishing. Clean exposed concrete surfaces and adjoining work stained by leakage of concrete.

3.08 RE-USE OF FORMS

A. Forms that are in good condition and have been cleaned, repaired, and resealed as required to achieve concrete of the specified quality and texture may be reused if approved by the Engineer. Split, frayed, delaminated or otherwise damaged form facing material will not be acceptable. Remove such material from the site. Renew form release coating as specified for new formwork.

B. Do not reuse wood formwork more than four times for concrete surfaces exposed to view.

C. Align and secure joints in a manner that will preclude offsets. Do not patch formwork unless accepted by the Engineer, in which case, patch holes and defects in forms with materials and methods that will not be reflected in the concrete.

3.09 FIELD QUALITY CONTROL

A. Inspect erected formwork, shoring, and bracing to ensure that the work is in accordance with formwork design, and that supports, fastenings, wedges, ties, and items are secure.

B. While placing concrete, provide quality control to assure that formwork and related supports have not been displaced, that loss of cement paste through joints is prevented and that completed work will be within specified tolerances.

C. During removal, verify that architectural features meet the form and texture requirements of the samples approved by the Engineer.

D. Check movement using methods, such as plumb lines, tell tales and survey equipment, as approved by the Engineer, to detect movement of formwork during concrete placement.

END OF SECTION
SECTION 03150
CONCRETE ACCESSORIES

PART 1 - GENERAL

1.01 DESCRIPTION
A. Section includes specifications for accessories for concrete structures.

1.02 REFERENCE STANDARDS
A. American Railway Engineering and Maintenance-of Way Association (AREMA):

B. State of California, Department of Transportation, Standard Specifications (Caltrans):
   1. Section 51 Concrete Structures
   2. Section 68 Subsurface Drains
   3. Section 75 Miscellaneous Metals
   4. Section 95 Epoxy

1.03 SUBMITTALS
A. Submit product data and manufacturer’s instructions for elastomeric bearing pads, waterstops, mortar, epoxies, and other items.

1.04 DELIVERABLES
A. Certificates of Compliance: Submit certificates of compliance for joint seals and elastomeric bearing pads.

PART 2 - PRODUCTS

2.01 MATERIALS
A. Concrete Anchorage Devices, Bolts and Inserts: Conform to the provisions of Caltrans Standard Specifications, Section 75, Miscellaneous Metal.

B. Expansion Joints, Joint Fillers and Sealers: Conform to the provisions in Caltrans Standard Specifications, Section 51, and AREMA Manual, Chapter 8. See Section 07250, Joint Sealants, for additional requirements.

C. Elastomeric Bearing Pads: Elastomeric bearing pads for railroad bridges shall conform to the details shown on the Contract Drawings and the requirements of AREMA Manual, Chapter 15, and the following additional requirements:
1. Elastomeric bearing pads shall be plain pads as specified in Caltrans Standard Specifications, Section 51, unless otherwise indicated, with a thickness as dimensioned on the Contract Drawings.

2. Provide holes as shown on the Contract Drawings for pads located at girder anchor rods.

D. Waterstops: Conform to the provisions in Caltrans Standard Specifications, Section 51-1.14, Waterstops.

E. Mortar: Conform to the provisions in Caltrans Standard Specifications, Section 51-1.135, Mortar.

F. Drain Pipe: Conforming to the provisions for pipe for edge drains and edge drain outlets in Caltrans Standard Specifications, Section 68-3, Edge Drains.

G. Embedded Junction Boxes and Conduit: Refer to Division 16, Electrical.

H. Embedded Drains, Drain Pipes, Reducers, and Fittings: Refer to Section 02630, Storm Drainage System.

I. Gel-Type Epoxy: Delta AS23-18 A&B gel-type epoxy or Engineer approved equal.

J. Epoxy binder: Conforming to the provisions in Caltrans Standard Specifications, Sections 95-1, General, and 95-2.01, Binder (Adhesive), Epoxy Resin Base.

2.02 MORTAR AND GROUT MIXES

A. Gel-Type Epoxy Sand Mortar: Mix mortar consisting of equal parts by volume of gel-type epoxy and dry silica sand in accordance with manufacturer's instructions.

B. Epoxy Grout: One part epoxy binder to three parts dry silica sand (fine aggregate), by volume.

C. Grout for baseplates and bedplates: Refer to Section 03300, Cast-In-Place Concrete.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Coordinate installation of accessories with Section 03300, Cast-in-Place Concrete, and related concrete sections.

B. Elastomeric Bearing Pads:

1. Bond pads to abutment seats and pier caps with epoxy.

2. Clean top and bottom surface of bearing pads with methyl ethyl ketone to remove all traces of mold release agents. When mating surfaces are
clean and dry, apply gel-type epoxy to a 5 mil thickness on the bridge seat and the bottom side of the bearing pad and then set pad and hold in the proper location on the bridge seat until the epoxy takes its initial set.

3. Just before setting beams, spread gel-type epoxy sand mortar on top of bearing pads to a thickness of approximately 1/4 inch to obtain uniform bearing. Scrape excess mortar from around bearing pads after beams are set.

C. Waterstops: Install waterstops as specified in Caltrans Standard Specifications, Section 51-1.14, Waterstops, and waterstop manufacturer’s written instructions.

D. Epoxy Grout: Apply where indicated on the Contract Drawings. Use in accordance with manufacturer’s instructions.

1. Follow manufacturer instructions regarding maximum pot life. In the event of high air temperatures, the time shall be shortened so that placement of the grout occurs while the material is still sufficiently liquid to adhere.

END OF SECTION
SECTION 03160
COLORED CONCRETE

PART 1 - GENERAL

1.01 DESCRIPTION
A. Section includes requirements for integrally colored concrete.

1.02 GENERAL
A. Provisions herein augment requirements specified under Sections 03300, Cast-in-Place Concrete, and 03350, Concrete Finishing, to add provisions specific to integrally colored concrete.

1.03 REFERENCES
A. American Society for Testing and Materials (ASTM International):
   1. C309 Liquid Membrane-Forming Compounds for Curing Concrete
   2. C979 Pigments for Integrally Colored Concrete

1.04 SUBMITTALS
A. Submit product data and manufacturer’s instructions for:
   1. Color additives
   2. Curing compounds
B. Samples for Color Verification:
   1. Submit 8 inch by 10 inch by 2 inch samples (or comparable size approved by the Engineer) of specified colors indicating color additive number(s) and required dosage rate(s).
C. Concrete Mix Designs: Submit under Section 03300, Cast-in-Place Concrete.

1.05 QUALITY ASSURANCE
A. Maintain consistency in workmanship throughout colored concrete work.
B. Installer Qualifications: Colored concrete work shall be performed by firm with five years experience with work of similar scope and quality.
C. Colored Concrete Mock-Up:
   1. Provide full-scale mock-up for the Engineer’s approval. Construct at least one month before observation and review to allow concrete to cure.
2. At location selected by the Engineer, place and finish 4 foot by 4 foot area for each concrete color and finish. Demonstrate methods of obtaining consistent visual appearance, including each forming and finishing condition required on Project using materials, workmanship, joint treatment, form ties, curing method, sealants, joint sealants, and patching techniques to be used throughout Project at color concrete.

3. Include specified concrete coverings, sealers, etc. as part of the mock-up if requested by the Engineer.

4. Retain samples of cements, sands, aggregates, and color additives used in mock-up for comparison with materials used in remaining Work. Make available to the Engineer upon request.

5. Accepted mock-up areas will be the visual standard for work of Section.

6. Remove when no longer required for comparison with finished work.

1.06 DELIVERY, STORAGE AND HANDLING

A. Color Additives: Comply with manufacturer’s instructions. Deliver color additives in original, unopened packaging. Store in dry conditions.

1.07 PROJECT CONDITIONS

A. Colored Concrete Environmental Requirements:

1. Schedule placing to minimize exposure to wind and hot sun before curing materials are applied.

2. Avoid placing concrete if rain, or frost is forecast within 24 hours. Protect fresh concrete from moisture and freezing.

B. Schedule delivery of concrete to provide consistent mix times from batching until discharge.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Cement, Water, and Other Admixtures: Refer to Section 03300, Cast-in-Place Concrete. Obtain each material, including cement and aggregates, from same source throughout color concrete work.

B. Cement: Cement shall be grey or white, as specified in the Contract Documents and as required to match samples available with the Engineer.

C. Integral Color Concrete Pigment: Conforming to ASTM C979, resistant to lime and other alkali, resistant to sunlight, and inorganic, and containing no carbon black. Provide ready-to-use, integral color material. Integral color material shall be Chromix additive by L.M. Scofield Company, or Davis Colors, or Engineer approved equal. Color additives shall contain pure, concentrated mineral
pigments specially processed for mixing into concrete.

1. **Colors:** To match samples available with the Engineer, utilizing cement, aggregates, and pigmented additive specified in the Contract Documents.

D. **Curing Compound for Colored Concrete:** Curing compound shall comply with ASTM C309 and be approved by color additive manufacturer for use with colored concrete. Provide W-1000 Clear Cure & Seal, manufactured by David Colors, or Engineer approved equal.

E. **Form Facing Materials:** Refer to Section 03100, Concrete Forming, for general requirements.

1. For formed colored concrete surfaces, provide non-porous surface such as steel, plastic, or high-density overlaid plywood with watertight joint seals to prevent leakage.

F. **Sealants for Colored Concrete:** Joint sealants shall be type specified in Section 07250, Joint Sealants. Provide in color to match colored concrete.

### 2.02 CONCRETE MIX DESIGNS

A. Concrete mix design shall conform to the requirements specified in Section 03300, Cast-in-Place Concrete, and the following additional requirements:

1. Match the sample available with the Engineer, utilizing the cement, aggregates, and pigmented additive specified in the Contract Documents.

2. Use of admixtures, in addition to pigmented additive itself, shall be subject to the written approval of the color additive manufacturer.

3. Dosage rate of color additive shall not exceed 10 percent of weight of cementitious materials in mix.

B. Maintain water content and control slump to maintain constant color.

C. **Color Additives:** Mix in accordance with manufacturer's instructions. Mix until color additives are uniformly dispersed throughout and disintegrating bags, if used, have disintegrated.

D. **Patching Mix:** If any patching is permitted, mix according to pigmented additive manufacturer's written instructions. Refer to Section 03170, Concrete Finishing, for additional requirements for patching.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

A. Refer to Sections 03300, Cast-in-Place Concrete, and 03170, Concrete Finishing, for general requirements for finishing and curing concrete.
B. Finishing and Curing of Colored Concrete:

1. Finish in accordance with color additive manufacturer’s written instructions and Section 03170, Concrete Finishing.

2. Colored Concrete: Cure in accordance with color additive manufacturer’s recommendations. Apply curing compound in accordance with curing compound manufacturer’s instructions. Apply curing compound at consistent time for each pour to maintain color consistency.

END OF SECTION
SECTION 03170
CONCRETE FINISHING

PART 1 – GENERAL

1.01 DESCRIPTION
A. Section includes specifications for the finishing and curing of formed and unformed concrete surfaces, including the repair of surface defects.

1.02 REFERENCE STANDARDS
A. American Association of State Highway and Transportation Officials (AASHTO):
   1. M182 Burlap Cloth Made from Jute or Kenaf and Cotton Mats
B. American Concrete Institute (ACI):
   1. 117 Specification for Tolerances for Concrete Construction and Materials
   2. 301 Specifications for Structural Concrete
   3. 308 Guide to Curing Concrete
   4. 503.4 Specification for Repairing Concrete with Epoxy Mortars
C. American Society for Testing and Materials (ASTM International):
   1. C33 Specification for Concrete Aggregates
   2. C150 Specification for Portland Cement
   3. C171 Specifications for Sheet Materials for Curing Concrete
   4. C309 Specification for Liquid Membrane-Forming Compounds for Curing Concrete
   5. C881 Specification for Epoxy-Resin-Base Bonding Systems for Concrete

1.03. SYSTEM DESCRIPTION
A. Finishes of formed concrete surfaces shall conform to applicable requirements of ACI 301.
B. Finishes for slabs and flatwork shall conform to applicable requirements of ACI 301.
C. Special architectural finishes for formed concrete surfaces shall conform to applicable requirements of ACI 301.
1.04. SUBMITTALS

A. Product Data: Submit manufacturers' product data for manufactured products.

B. Samples: Review by the Engineer will be for color and texture only. Approved samples will become the Engineer's control samples.

1. Submit samples at least 12 inches by 12 inches in size of each type of sand blast finish, indicating materials and methods used to produce the sand blast finishes.

2. Submit samples of seeded aggregate where washed aggregate finish is indicated.

1.05. QUALITY ASSURANCE

A. Requirements of Regulatory Agencies: Comply with air pollution regulations of governing authorities for sandblasting activities and operations.

B. Site Mock-Ups:

1. Exposed Finishes: Provide site mock-ups, at least 3 feet by 4 feet in size, of finishes of formed surfaces in exposed locations and of exposed slab finishes for the Engineer's approval.

2. Architectural Concrete: Provide site mock-ups of architectural concrete, at least 8 feet by 10 feet in size, showing finish texture and pattern of exposed formed concrete surfaces for Engineer's approval.

3. Include specified concrete coverings, hardeners, sealers, etc. as part of the mock-up if requested by the Engineer.

4. Provide the number of mock-up panels required necessary to obtain the Engineer's approval of pattern, texture, and color of panel.

5. Maintain approved mock-ups and use as the standard for the aesthetic quality of the surface finish for work represented by mock-ups. Remove mock-ups when permitted by the Engineer.

6. refer to Section 03160, Colored Concrete, for additional mock-up requirements for integrally colored concrete.

PART 2 - PRODUCTS

2.01 REPAIR AND FINISHING MATERIALS

A. Portland Cement: ASTM C150, Type I or II, of same brand as used in the work. Furnish white Portland cement where required to produce color matching color of surrounding concrete.
B. Aggregate:

1. For Bonding Grout: ASTM C33, washed clean sand passing a No. 30 sieve.
2. For Patching Mortar: ASTM C33, washed clean, graded fine aggregate of suitable size for areas to be repaired. Clean coarse aggregate up to Size No. 8 may be added for repair of larger pockets and voids.
3. For Washed Aggregate Finish: Washed clean, match approved sample.

C. Commercial Patching Mortar: A structural repair mortar may be furnished if appropriate for the use and approved by the Engineer.

D. Epoxy Patching Mortar: As specified in ACI 503.4 for Epoxy Mortar.

E. Epoxy Adhesive: ASTM C881, Type II or Type V, epoxy-based bonding agent.

F. Color Hardener: As specified in the Contract Documents.

2.02 REPAIR MIXES

A. Bonding Grout: 1 part Portland cement to 1 part No. 30 mesh sand, mixed to the consistency of a thick cream.

B. Patching Mortar: Make the patching mortar of the same materials and of approximately the same proportions as used for the concrete, except omit the coarse aggregate. Use not more than 1 part Portland cement to 2-1/2 parts sand by damp loose volume, and substitute white Portland cement for a portion of the regular gray Portland cement to produce patching mix matching the surrounding concrete in color when dry. Determine the proportion of white Portland cement by trial mixes and test areas, prior to repair of actual defective areas.

2.03 CURING MATERIALS

A. Damp Curing Materials: Non-staining.

1. Waterproof Sheet Materials: ASTM C171, waterproof paper with white paper face, polyethylene film pigmented white, or white burlap-polyethylene sheathing.

2. Burlap: AASHTO M182, of class or weight suitable for the use and location. Do not use burlap where concrete is exposed to direct sunlight.

B. Curing Compound: ASTM C309, liquid membrane-forming curing compound, Type I, Class A or B, as appropriate for the use or location.

1. Where concrete surfaces will receive architectural finishes, such as resilient floor coverings, paint, or membrane waterproofing, membrane-forming curing compound shall not leave a coating or residue which will impair bond of adhesives, paints, and coatings with concrete.
C. Curing Compound for Colored Concrete: For concrete colored with color hardener, use curing compound recommended by the manufacturer of the color-hardener material. For integrally colored concrete, refer to Section 03160, Colored Concrete, for curing compound.

PART 3 - EXECUTION

3.01 REPAIR OF SURFACE DEFECTS

A. Repair Standards: Repair of surface defects shall conform to applicable requirements of ACI 301. When using epoxy mortar, conform to applicable requirements of ACI 503.4.

B. Surface Defects:

1. Begin repair of surface defects immediately after form removal. For repair with epoxy mortar, concrete shall be dry.

2. Surface defects are defined to include: form-tie holes, air voids and pockets, bug holes with a nominal diameter or depth greater than 1/4-inch, honeycombed areas, rock pockets, visible construction joints, fins and burrs.

3. Repair of surface defects shall be tightly bonded and shall result in concrete surfaces of uniform color and texture, matching adjacent surfaces, and free of shrinkage cracks.

C. Repair Work:

1. Remove honeycombed and other defective concrete down to sound concrete. Saw-cut the edges perpendicular to the surface or slightly undercut. Feather-edges will not be permitted. Dampen the area to be patched and an area at least 6 inches wide surrounding it to prevent absorption of water from the patching mortar.

2. Where rock pockets or similar defects or voids expose steel reinforcement, cutout to solid surface behind the reinforcing steel to provide suitable key-lock for patching mortar. Envelop exposed reinforcing bar with patching mortar.

3. Bond patching mortar to concrete with bonding grout or epoxy adhesive. Brush bonding grout well onto the concrete. Bond commercial patching mortar to concrete in accordance with the manufacturer's instructions.

4. After surface water has evaporated from the area to be patched, brush the bond coat well into the surface. When the bond coat begins to lose the water sheen, apply the patching mortar. Compact the mortar into place and strike off so as to leave the patch slightly higher than the surrounding surface. To permit initial shrinkage, leave the patch undisturbed for at least 1 hour before being finally finished. Keep the patched area damp for 7 days.
5. Neatly finish patched surfaces to match adjacent surrounding surface texture of concrete. Grind or fill surfaces to produce level and plumb, true planes.

6. For walls exposed in the finish work, form tie holes shall be patched and finished flush with adjacent surface. For holes passing entirely through walls, use a plunger type injection gun or other suitable device shall be used to completely fill the holes.

7. In order to patch honeycombed areas or rock pockets which are too large and unsatisfactory for mortar patching, cut out to solid surface, key, and pack solid with matching concrete to produce firm bond and flush surface. Patching shall match texture of adjacent surfaces where exposed in the finished work.

8. Remove repair work in exposed locations which does not match the texture and color of surrounding adjacent surfaces or which was not well performed and perform again until the repair work conforms to specified requirements.

9. Remove fines and loose materials from surfaces to receive membrane waterproofing, and patch voids and cracks flush with adjacent surfaces.

10. Cure completed repairs as specified herein under Curing.

3.02 FINISHING OF FORMED SURFACES

A. Unexposed Surfaces:

1. Concrete which will not be exposed in the completed structure shall be any form finish as specified in Section 03100, Concrete Forming, and ACI 301 for rough form finish.

2. Concrete to receive membrane waterproofing shall receive a "smooth form finish" in accordance with ACI 301.

B. Exposed Surfaces: Unless indicated otherwise, concrete which will be exposed in the completed structure shall receive the following finishes as indicated:

1. Smooth Form Finish: Conform to ACI 301

2. Smooth Rubbed Finish: Conform to ACI 301

3. Grout Cleaned Finish: Conform to ACI 301

4. Unspecified Finish: When finish is not indicated, provide "smooth form finish" as specified above.
C. Sand Blast Finish:

1. Blasting Operations and Requirements:
   a. Apply sandblasted finish to exposed concrete surfaces where indicated.
   b. Perform sand blasting at least 72 hours after placement of concrete. Coordinate with formwork construction, concrete placement schedule, and formwork removal to ensure that surfaces to be blast finished are blasted at the same age for uniform results.
   c. Determine type of nozzle, nozzle pressure, and blasting techniques required to match the Engineer’s control samples.
   d. Abrasive blast corners and edge of patterns carefully, using back-up boards, to maintain uniform corner or edge line.

2. Depths of Cut: Use an abrasive grit of proper type and gradation to expose aggregate and surrounding matrix surface to match the Engineer’s control samples as follows:
   a. Brush Sand Blast Finish: Remove cement matrix to expose face of fine aggregate; no reveal.
   b. Light Sand Blast Finish: Expose fine aggregate with occasional exposure of coarse aggregate; maximum 1/16-inch reveal.
   c. Medium Sand Blast Finish: Generally expose coarse aggregate; 3/16-inch to 1/4-inch reveal.

3. Surface Continuity: Perform sand blast finishing in as continuous an operation as possible, utilizing the same work crew to maintain continuity of finish on each surface or area of work. Maintain patterns of variances in depths of cuts as indicated.

4. Construction Joints: Use technique approved by the Engineer to achieve uniform treatment of construction joints.

5. Protection and Repair:
   a. Protect adjacent materials and finishes from dust, dirt, and other surface or physical damage during abrasive blast finishing operations. Provide protection as required and remove from site at completion of the work.
   b. Repair or replace other work damaged by finishing operations.

6. Clean-up: Maintain control of concrete chips, dust, and debris in each area of the work. Clean up and remove such material at the completion of each day of operation. Prevent migration of airborne materials by use of tarpaulins, wind breaks, and similar containing devices.
3.03 SLABS AND FLATWORK

A. Placement and Finishing Standards: Place, consolidate, and finish slabs and flatwork in accordance with applicable requirements of ACI 301. Coordinate with Section 03300, Cast-In-Place Concrete, as applicable.

B. Placement:

1. Place slabs and flatwork and finish monolithically. Strike off and screed slabs to true, plane surfaces at required elevations, and thoroughly compact concrete with vibrators, floats, and tampers to force coarse aggregate below the surface. Finish slab within four hours of concrete placement.

2. Whether indicated or not, in areas where drains occur, slope finished slab to drains. Slope shall be a minimum of 1/8-inch per foot unless otherwise indicated.

C. Slab Finishes: Unless indicated otherwise, slabs and flatwork shall receive the following finishes as indicated:

1. Scratched Finish: Conform to ACI 301. Provide "scratched finish" for slab substrates to receive cementitious toppings or finishes, such as terrazzo or mortar setting bed for ceramic tile.

2. Floated Finish: Conform to ACI 301. Provide "floated finish" for track slabs and mud slabs and for slabs and flatwork to receive roofing and membrane waterproofing.

3. Troweled Finish: Conform to ACI 301. Provide "troweled finish" for interior slabs and flatwork to be exposed in the completed structure, for slabs to receive resilient floor coverings, and for flatwork to receive elastomeric bearing pads.

4. Broom Finish: Conform to ACI 301. Exact texture and coarseness of the broom finish shall match the approved site mock-up. Provide fine or medium-coarse "broom finish" as indicated for exterior sidewalks and paving, garage floors (other than parking garages), exterior ramps, equipment and transformer pads, and subway invert slab.

5. Unspecified Finish: When finish is not indicated or specified, provide finishes as specified in ACI 301.

6. Washed Aggregate Finish: Evenly distribute seeded aggregate over a floated finish. Tamp surface to bring fines to surface completely covering seeded aggregate. Apply troweled finish. Apply surface retarder according to manufacturer's instructions and recommendations. Wash surfaces with water and finish with stiff bristle brush until seeded aggregate is uniformly exposed.
7. Swirl Pattern Finish: After basic floating operations have been completed, hand float slabs using wood float to produce a continuous swirl patterned surface, free from porous spots, irregularities, depressions, and small pockets or rough spots such as may be caused by accidentally disturbing particles of coarse aggregate embedded near the surface. Use natural arm circular motion to produce rows of approximately 1-foot radius swirl pattern covering approximately half of the preceding row with each successive row. Provide swirl pattern finish for parking garage floors.

D. Surface Tolerances and Finishes: Refer to Tolerances specified herein.

1. Flat Tolerance: Slabs and flatwork with "troweled finish" and with "nonslip finish."

2. Straightedge Tolerance: Slabs and flatwork with fine "broom finish" or medium-coarse "broom finish."


E. Joints:

1. Construction, expansion, isolation, and contraction joints shall be located as indicated. Construction joints shall act as contraction joints. Where additional contraction joints are required to prevent shrinkage cracks, saw-cut such joints. All joints shall be straight and true to line.

2. Mark-off lines or edges at formed construction and expansion joints shall be finished with 1/4-inch radius curved edging tool, neat and true to line, uniform throughout.

3.04 TOLERANCES

A. Formed Surfaces: Conform with applicable requirements of ACI 117.

1. Where elastomeric bearing pads are indicated, the level plane upon which bearing pads are placed shall not vary more than 1/16-inch from a 10-foot straightedge placed in any direction across the area and the area shall extend a minimum of 1 inch beyond the limits of the pads.

2. Bearing surfaces of girders on a slope or girders with a camber shall be finished on a horizontal/level plane so that loads are uniformly distributed over the entire surface of the elastomeric bearing pads.

3. The finished plane shall not vary more than 1/8-inch from the elevation indicated.

B. Slabs and Flatwork: Conform to applicable classification requirements of ACI 117, as follows:
1. Very Flat Tolerance: True plane with maximum variation of 1/8-inch in 10 feet when measured with a 10-foot straightedge placed anywhere on the slab in any direction.

2. Flat Tolerance: True plane with maximum variation of 3/16-inch in 10 feet when measured with a 10-foot straightedge placed anywhere on the slab in any direction.

3. Straightedge Tolerance: True plane with maximum variation of 5/16-inch in 10 feet when measured with a 10-foot straightedge placed anywhere on the slab in any direction.

4. Bullfloated Tolerance: True plane with maximum variation of 1/2 inch in 10 feet when measured with a 10-foot straightedge placed anywhere on the slab in any direction.

3.05 CURING

A. Curing Standards: Cure concrete in accordance with applicable requirements of ACI 301 and ACI 308, except that the duration of the curing period shall be ten days. Curing of concrete shall also conform to Section 03300, Cast in Place Concrete.

B. Curing Requirements:

1. Cure concrete with waterproof sheet materials, damp burlap, or curing compounds.

2. Do not use curing compounds on surfaces when their use may be detrimental to bonding of concrete, mortar, membrane waterproofing, calking and sealants, adhesives, plaster, paint, or the specified surface finish or coating.

3. Cure color-hardener finished slabs and flatwork as recommended by the color-hardener material manufacturer.

4. Cure integrally colored concrete as specified in Section 03160, Colored Concrete, and as specified herein.

5. At the expiration of the curing period, clean concrete surfaces of all curing media.

C. Damp Curing:

1. Vertical surfaces shall be cured by keeping the forms wet at all times and by leaving the forms in place as long as possible as specified in Section 03100, Concrete Forming. After removal of forms, concrete shall be kept continuously damp by fog spraying or otherwise washing down the concrete in an accepted manner until ten days after placing. Protect exposed surfaces by covering with sheet materials or burlap kept continuously moist.
2. Horizontal surfaces shall be cured and protected by covering the finished surfaces with waterproof sheet materials or damp burlap, left in place for a minimum of ten days and kept continuously moist.

3. Fog spray freshly placed slabs until finishing operations commence. Allow no slabs to become dry until finishing operations are complete.

D. Curing Compound: Non-structural concrete, such as slabs-on-grade, may be cured by membrane curing compound in lieu of wet curing specified above. Apply curing compound in accordance with applicable requirements of ACI 308 and manufacturer’s instructions. Apply without delay on newly finished surface. Protect integrity of membrane and touch up damaged spots immediately.

3.06 PROTECTION

A. Protect exposed concrete surfaces, including flatwork, as required to prevent damage from impact or strains.

B. Protect fresh concrete from drying winds, rain, damage, or soiling.

C. Refer to Section 03300, Cast-In-Place Concrete, for additional requirements.

D. Prevent contamination of planting areas during washing of washed aggregate finish.

END OF SECTION
SECTION 03200
CONCRETE REINFORCING

PART 1 - GENERAL

1.01 DESCRIPTION

A. Section includes specifications for concrete reinforcing.

1.02 REFERENCE STANDARDS

A. American Concrete Institute (ACI):

1. 301 Specifications for Structural Concrete for Buildings.
2. 315 Details and Detailing of Concrete Reinforcement.

B. ASTM International (ASTM):

1. A82 Specification for Steel Wire, Plain, for Concrete Reinforcement
2. A185 Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement
3. A497 Specification for Steel Welded Wire Fabric, Deformed, for Concrete Reinforcement
4. A706 Specification for Low-Alloy Steel Deformed Bars for Concrete Reinforcement
5. A767 Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement
6. A775 Specification for Epoxy-Coated Reinforcing Steel Bars
7. A884 Specification for Epoxy-Coated Steel Wire and Welded Wire Fabric for Reinforcement
9. D3963 Specification for Epoxy-Coated Reinforcing Steel

C. American Welding Society (AWS):

1. D1.4 Structural Welding Code – Reinforcing Steel
2. QC1 Specification for AWS Certification of Welding Inspectors

D. Concrete Research Standards Institute (CRSI):

1. Manual of Standard Practice
2. Placing Reinforcing Bars

E. State of California, Department of Transportation, Standard Specifications (Caltrans):
   1. Section 52 Reinforcement
   2. Section 83 Railings and Barriers
   3. Section 90 Portland Cement Concrete

F. State of California, Department of Transportation, Test Methods (Caltrans):
   1. 417 Soils and Water for Sulfate Content
   2. 422 Testing Soils and Water for Chloride Content

1.03 SUBMITTALS

A. Reinforcing Steel Shop Drawings: Indicate sizes, spacing, bending and cutting schedules, splices and laps, supporting and spacing devices, and quantities. Coordinate drawings to prevent reinforcing steel from interfering with the placement of embedded items.

B. Mill Test Reports: Submit certified mill test reports (tensile and bending) for each heat or melt of steel showing physical and chemical analyses before delivery of reinforcing material to the job site.

C. Certificates of Compliance: Submit in accordance with Caltrans Standard Specifications Section 52-1.04, Inspection. For galvanized reinforcing bars, submit certificates of compliance with ASTM A 767.

D. Submit manufacturer's product data and installation instructions for proprietary mechanical coupler systems when such splicing methods are permitted.

E. When galvanized or epoxy-coated reinforcing bars are indicated, furnish two 12-inch long samples and two additional samples bent to minimum radius of the rebar from each lot shipped to the work site.

F. Qualifications of welding operators, welding processes, and procedures. For welders, furnish welding certificates or affidavits attesting to the welders' qualifications to perform the indicated welding in accordance with applicable requirements of AWS D1.4.

1.04 DELIVERABLES

A. Submit copies of inspection and test reports for welding as required in this Section.
1.05 QUALITY ASSURANCE

A. Perform work in accordance with the requirements of applicable building codes, CRSI Manual of Standard Practice, and CRSI Placing Reinforcing Bars.

B. Perform work in accordance with the requirements of ACI 301 and ACI 315.

C. Qualifications of Welding Inspector: Welds to be inspected by the Contractor shall be inspected and certified by a Contractor-employed AWS Certified Welding Inspector (CWI), certified in accordance with AWS QC 1.

D. Qualification of Personnel Performing Nondestructive Testing: Personnel performing nondestructive testing, who are Contractor-employed, shall be qualified and certified in accordance with SNT-TC-1A. Only persons certified for NDT Level I and working under a NDT Level II person or persons certified for NDT Level II may perform nondestructive testing.

1.06 DELIVERY, STORAGE AND HANDLING

A. Ship and store reinforcement with bars of the same size and shape fastened in bundles with durable tags, marked in a legible manner with waterproof markings showing the same designations as shown on the submitted placing drawings.

B. Store reinforcement off the ground, protect from moisture, and keep free from dirt, oil, or other contaminants. Steel, which cannot be properly identified, will be rejected and shall be immediately removed from the work site.

C. Handle and store galvanized and epoxy-coated reinforcement in a manner which will prevent damage to the coatings. For epoxy-coated reinforcement, comply with the requirements of ASTM D 3963.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Reinforcing Steel Bars: ASTM A706

B. Reinforcing Steel Wire: ASTM A 82, cold drawn

C. Welded Steel Wire Fabric – Plain Wire: ASTM A 185, uncoated finish

D. Welded Steel Wire Fabric – Deformed Wire: ASTM A 497, uncoated finish

E. Welded Steel Wire Fabric – Epoxy-Coated: ASTM A 884

F. Epoxy-coated Reinforcing Bars: ASTM A 706 epoxy-coated in accordance with ASTM A 775 and ASTM D 3963. Coating material shall conform to ASTM A 775 and ASTM D 3963, Annex 1, green in color. Bars shall be cut and bent cold before applying coating material.

G. Galvanized Reinforcing Bars: ASTM A 706 galvanized in accordance with ASTM A 767, Class I coating. Bars shall be cut and bent cold before galvanizing.
H. Mechanical Splice Coupler: Provide bar splicing connections produced by threaded reinforcing bar ends and threaded coupler, or by sleeves hydraulically pressed or forged onto butt-ended reinforcing bars. Mechanical splice couplers shall be capable of being installed in the clear space indicated and to provide the required clearances. The strength of the splice in tension and compression shall be a minimum of 125 percent of the yield strength of the connected reinforcing bars.

I. Welding Electrodes: E90 meeting the requirements of AWS D1.4.

2.02 ACCESSORIES

A. Steel Tie Wire: No. 16 gage or heavier, black or galvanized, soft or commercial grade steel tie wire. For galvanized reinforcement, provide zinc-coated wire. For epoxy-coated reinforcement, provide nylon-, epoxy-, or plastic-coated wire.

B. Chairs, bolsters, bar supports, and spacers:
   1. Metal, plastic tipped, in accordance with the requirements of CRSI Manual of Standard Practice for reinforced concrete construction.
   2. Sized and shaped for strength and support of reinforcement during installation and placement of concrete.
   3. For galvanized reinforcement, provide all galvanized accessories.
   4. For epoxy-coated reinforcement, provide accessories which are nylon-, epoxy-, or plastic-coated.

2.03 GROUT

A. Bonding Material for Bonding Dowels: As specified in Caltrans Standard Specifications, Section 83-2.02D(1).

B. Non-Shrink Grout: Grout shall be a premixed package blend of Portland cement, graded silica sand, and water reducing, plasticizing and time release expansion agents, which conforms to ASTM C1107, Grade B, and provides a minimum 5000 psi compressive strength at 28 days. Mix grout in accordance with the manufacturer’s recommendations. Water shall comply with the provisions in Caltrans Standard Specifications, Section 90-2.03, Water.
   1. Admixtures shall not contain more than 0.05 percent soluble chlorides when tested in conformance with California Test 422 nor more than 0.25 percent soluble sulfates, as SO$_4$ when tested in conformance with California Test 417.

2.04 FABRICATION

A. Fabricate in accordance with the requirements of ACI 315.
B. Locate splices not indicated on the Contract Drawings at point of minimum stress.

C. Repair of Damaged Coatings:
   1. Epoxy: Repair in accordance with the provisions in Caltrans Standard Specifications, Section 52, Reinforcement.
   2. Galvanized: Repair as specified in ACI 301, ASTM A 767, ASTM A 775, ASTM A 884, and ASTM D 3963, as applicable.

D. Welding:
   1. Welding of reinforcement, where indicated and approved, including preparation of bars, shall conform with applicable requirements of AWS D1.4.
   2. Clean bars of oil, grease, dirt, and other foreign matter and flame-dry before welding. Preheat bars welding in accordance with AWS D1.4, Chapter 5.
   3. Butt Welded Splices: Use full penetration butt welds in accordance with the provisions in Caltrans Standard Specifications, Section 52, Reinforcement, unless another weld splice type is indicated or approved.

PART 3 - EXECUTION

3.01 PREPARATION
   A. Before placing concrete, clean reinforcement of foreign particles, including mortar, oil, grease, dirt, loose mill scale, rust and any other coating that will prevent or reduce bond.
   B. Place in position, support, and secure reinforcement to prevent displacement during concrete placement. Do not deviate from alignment or spacing as shown on the Contract Drawings.

3.02 CLEANING, BENDING, PLACING, AND SPLICES
   A. Perform work in accordance with the provisions in Caltrans Standard Specifications, Section 52, Reinforcement, and as specified herein.
   B. Perform installation of mechanical coupler and tightening for joint assembly in accordance with the coupler manufacturer’s installation instructions and recommendations.

3.03 DRILLING AND BONDING DOWELS
   A. Drilling and bonding dowels shall conform to the details shown on the Contract Drawings, the provisions in Caltrans Standard Specifications, Section 83-2.02D(1), and as specified herein.
B. If reinforcement is encountered during drilling, before the specified depth is attained, notify the Engineer. Unless the Engineer approves coring through the reinforcement, the hole will be rejected. If hole is rejected, drill a new hole, in which reinforcement is not encountered, adjacent to the rejected hole to the depth shown on the Contract Drawings. Grout rejected hole.

C. Dowels shall conform to the provisions for reinforcing steel bars specified herein.

3.04 DRILLING AND GROUTING DOWELS

A. Drilling and grouting concrete shall consist of drilling through reinforced concrete bridge members, placing reinforcement and filling holes with non-shrink grout, and shall conform to the details shown on the Contract Drawings, the provisions in Caltrans Standard Specifications, Section 83-2.02D(1), and as specified herein.

B. If reinforcement is encountered during drilling, before the specified depth is attained, notify Engineer. Unless the Engineer approves coring through the reinforcement, the hole will be rejected. If hole is rejected, drill new hole, in which reinforcement is not encountered, adjacent to the rejected hole to the depth shown on the Contract Drawings. Grout rejected hole.

C. Dowels shall conform to the provisions for reinforcing steel bars specified herein.

D. Clean concrete areas to be in contact with grout of all loose or foreign material that would in any way prevent bond between the concrete surfaces, flush flushed with water, and allow to dry to a surface dry condition immediately prior to grouting.

E. After placement of reinforcement, seal ends of the drilled hole containing the reinforcement, with one vent tube and one injection feed tube. Place tubes in the hole in a manner which will allow the air to vent and the hole to be completely filled with grout. Achieve sufficient pressure to ensure that the hole is free of voids. Pump grout through the holes and continually waste grout until no visible slugs or other visible evidence of water or air are ejected and the efflux time of ejected grout is not less than 11 seconds.

F. Prevent grout from falling into any waterway and on public traffic, from flowing across shoulders or lanes occupied by public traffic, and from flowing into gutters or other drainage facilities.

3.05 FIELD QUALITY CONTROL

A. Inspection and testing of welds shall be performed by an approved Inspection and Testing Agency retained by the Contractor:

1. Visually inspect reinforcing bar welds.

2. Tension tests of welded butt joints shall be performed on sample welds produced by the Contractor in accordance with ASTM E8.

3. Non destructive tests of installed welded butt joints shall be performed in accordance with ASTM E165.
4. Inspections and tests shall be performed in accordance with the applicable requirements of AWS D1.4, Chapters 6 and 7.

END OF SECTION
SECTION 03300
CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.01 DESCRIPTION
A. Section includes specifications for cast-in-place Portland cement concrete including mix designs, delivering, and placing.

1.02 REFERENCE STANDARDS
A. American Concrete Institute (ACI):
   1. 211.1 Selecting Proportions for Normal, Heavyweight and Mass Concrete
   2. 301 Specifications for Structural Concrete for Buildings
   3. 302.1R Guide for Concrete Floor and Slab Construction
   4. 304R Guide for Measuring, Mixing, Transporting and Placing Concrete
   5. 305R Hot Weather Concreting
   6. 306.1 Cold Weather Concreting
   7. 308 Standard Practice for Curing Concrete
   8. 318 Building Code Requirements for Reinforced Concrete
B. American Society of Testing and Materials (ASTM International):
   1. C31 Making and Curing Concrete Test Specimens in the Field
   2. C33 Concrete Aggregates
   3. C39 Compressive Strength of Cylindrical Concrete Specimens
   4. C94 Ready-Mixed Concrete
   6. C138 Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
   7. C143 Test Method for Slump of Portland Cement Concrete
   8. C150 Portland Cement
9. C 171 Sheet Materials for Curing Concrete
10. C173 Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
11. C231 Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
12. C260 Air-Entraining Admixtures for Concrete
13. C494 Chemical Admixtures for Concrete
14. C579 Test Methods for Compressive Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings and Polymer Concretes
15. C618 Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
16. C827 Test Method for Change in Height at Early Ages of Cylindrical Specimens from Cementitious Mixtures
17. C928 Packaged, Dry, Rigid-Hardening Cementitious Materials for Concrete Repairs
18. C1017 Chemical Admixtures for Use in Producing Flowing Concrete.
20. C1059 Latex Agents for Bonding Fresh To Hardened Concrete
21. C1116 Fiber-Reinforced Concrete and Shotcrete
22. D1751 Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
23. E329 Agencies Engaged in Construction Inspection and/or Testing.

C. State of California, Department of Transportation, Standard Specifications, (Caltrans):
   1. Section 51, Concrete Structures

D. U.S. Army Corps of Engineers, Concrete Research Division (CRD):
   1. C621 Nonshrink Grout

1.03 SUBMITTALS

A. Concrete Mix Designs: Submit mix designs for each class of concrete. Indicate locations to be used. Include names and brands of materials, proportions,
slump, strength, gradation of aggregates. Include laboratory test reports of trial strength and shrinkage tests.

B. Product Data: Submit manufacturer's product data for proposed products, including epoxy adhesive, grout, and concrete admixtures.

C. Shop Drawings:

1. Submit drawings that indicate the locations of all joints in concrete, including construction joints, expansion joints, isolation joints, and contraction joints. Coordinate with the requirements specified in Section 03100, Concrete Forming.

2. Submit drawings that indicate concrete placement schedule, method, sequence, location, and boundaries. Include each type and class of concrete, and quantity in cubic yards.

3. Submit drawings that detail the type, size, and location of all pipes, conduit, embeds, blockouts, and recesses for all vertical and horizontal concrete construction.

4. Reproductions of contract drawings are unacceptable.

D. Submit for the Engineer’s approval the name, address, and telephone number of the laboratory, agency, mill, or ready-mix plant which the Contractor intends to engage to design the concrete mixes.

1.04 DELIVERABLES

A. Certificates of Compliance: For each shipment of materials, submit evidence of compliance with Specification requirements for cement, aggregate, and admixtures.

B. Batch Tickets: Submit a delivery ticket with each batch of concrete delivered to the site in accordance with the requirements of ASTM C94.

C. Records and Reports: Report the location in the finished work of each mix design, and the start and completion times of placement of each batch of concrete placed for each date concrete is placed.

1.05 QUALITY ASSURANCE

A. Qualifications of Mix Design Source: Obtain mix designs, including recommended amounts of admixture and water to be used in the mixes, from a qualified independent testing laboratory or agency, or from a mill or ready-mix plant, properly equipped to design concrete mixes. The laboratory, agency, mill, or ready-mix plant shall meet applicable requirements of ASTM E329.

B. Comply with ACI 304R.
PART 2 - PRODUCTS

2.01 MATERIALS

A. Concrete Materials:

1. Portland Cement: Conforming to ASTM C150 Type I or II
2. Air-entraining admixture: Conforming to ASTM C260
3. Fine aggregate: Conforming to ASTM C33
4. Coarse aggregate: Conforming to ASTM C33
5. Water: Potable, clear and free of injurious amounts of oil, acid, alkali, salts, organic matter, and any other substances that may be deleterious to concrete or steel.
6. Corrosion inhibitor: Equivalent in quality and performance to one of the following:
   a. DCI by Grace Concrete Products
   b. Rheocrete 222 by Master Builders, Inc.

B. Optional Concrete Admixtures and Cementitious Materials: At Contractor’s option and with Engineer’s acceptance, include accepted concrete admixtures and cementitious materials in the mix to improve the water-cement ratio or water-cementitious ratio or workability of the concrete, providing strengths specified and other desirable characteristics of the concrete can be achieved and maintained. Obtain Engineer’s acceptance of proposed admixtures prior to use. Indicate admixtures in design mix. Add admixtures at batch plant and add in solution form, except as otherwise approved.

1. Chemical Admixtures, Water-Reducing: ASTM C494, Type A
2. Pozzolanic Admixtures: ASTM C618, Class N or F
3. Fly Ash: ASTM C618, Class F, with a maximum of 25 percent retained on the No. 325 mesh sieve and a loss on ignition of 1.0 percent maximum.
4. Pigments for integrally colored concrete: Refer to Section 03160, Colored Concrete.
5. Chemical Admixtures, Plasticizing: ASTM C1017, or ASTM C494 Type F or Type G, high-range water-reducing admixtures.
6. Prohibited Admixtures: Admixtures containing chlorides or sulfides are not acceptable.
C. Grout:

1. Cementitious Grout: Provide a prepackaged, nonshrink, nonmetallic, noncorrosive cement-based grout conforming to the following requirements:
   a. ASTM C1107, Grade B or C, as appropriate for the condition or use. Grout shall be manufactured specifically for use in supporting heavy loads and shall have a minimum compressive strength of 7,500 psi at 28 days.
   b. Shrinkage at 28 days: No shrinkage before hardening (0.00 shrinkage when tested in accordance with ASTM C827); no shrinkage after hardening (0.00 shrinkage when tested in accordance with CRD-C621.)

2. Epoxy Grout: Provide a nonshrink, nonmetallic, noncorrosive epoxy grout conforming to the following requirements:
   a. Grout shall be a 3-component epoxy resin system (two liquid epoxy components and one inert aggregate filler component) manufactured specifically for use in supporting heavy loads. The minimum compressive strength shall be 10,000 psi at seven days when tested in accordance with ASTM C579.
   b. Shrinkage at 28 days: None (0.00 shrinkage when tested in accordance with ASTM C827 modified procedure) with a minimum bearing area (EBA) of 95 percent coverage of the tested base plate.

3. Cementitious Grout for Repairs to Concrete Pavements and Structures: Provide a prepackaged, nonshrink, nonmetallic, noncorrosive cement-based grout conforming to the following requirements:
   b. Rapid-hardening when mixed with water, forming a permanent bond. Initial set shall be in 30 minutes.

D. Expansion Joint Filler: Pre-molded asphalt impregnated felt conforming to ASTM D1751, 1/2-inch unless otherwise indicated on the Contract Drawings.

E. Polypropylene Fibers:

1. Fibrillated Polypropylene Fibers: 100 percent virgin polypropylene, MD Graded, containing no reprocessed olefin materials, and specifically manufactured for use as concrete secondary reinforcement, and to protect concrete from stresses which cause cracking initially after placement.
2. Monofilament Polypropylene Fibers: 100 percent virgin polypropylene, MD Graded, containing no reprocessed olefin materials, and specifically manufactured to protect concrete from stresses which cause cracking initially after placement.

3. The physical characteristics of the polypropylene fibers shall be as follows:
   a. 1/2 inch or 3/4 inch polypropylene fibers, maximum 3 denier, complying with ASTM C1116, Type III.
   b. Not less than 50 million individual fibers per pound.

4. Supply fibers in cellulose fiber bags which disintegrate and disperse fibers during mixing. Other packaging and dispensing means may be acceptable.

F. Bonding Agent: ASTM C1059 for bonding fresh to hardened concrete.

G. Curing Materials: Refer to Section 03170, Concrete Finishing.

H. Expanded Polystyrene: As specified in the Caltrans Standard Specifications, Section 51-1.12D.

2.02 MIX CRITERIA

A. Ready-mix concrete shall conform to ASTM C94, Option B. Proportions shall conform to ACI 211.1, except as modified below.

B. Concrete shall comply with ACI 301 and ACI 318, as applicable. Ensure that mix designs will produce concrete suited for proper placement and finishing.

C. Concrete mix:
   1. Compressive strength: 4,000 psi minimum at 28 days, unless otherwise indicated on the Contract Drawings.
   2. Entrained air content: 3 to 4 percent, except as indicated in the following:
      a. 2 to 4 percent for concrete with a 28 day compressive strength of 5000 psi or greater.
      b. 3 percent maximum for concrete used for cast-in-place concrete station platforms ramps, and stairs.
   3. Corrosion inhibitor added in accordance with the manufacturer's instructions; 2 gallons DCI or 1 gallon Rheocrete 222 per cubic yard of concrete, minimum.
   4. Include polypropylene fibers in concrete mix of the type shown and where indicated in the Contract Documents. For uniform distribution,
mix in truck for a minimum of 20 minutes after fiber addition. Add fibers at the batch plant to ensure proper mixing. Use the following dosages:

a. **Typical**: One pound per cubic yard of concrete unless greater dosage is recommended by the fiber manufacturer.

b. **Bus Access Lanes and Bus Stop Pads**: One and one half pounds per cubic yard.

5. Design concrete mix for pumping to meet requirements specified herein except that mix may be richer in lubricating components in order to allow proper pumping, subject to the Engineer’s approval.

D. Each trial mix shall be developed by an independent testing laboratory in accordance with the requirements of ACI 318 and ACI 301. Quality control relating to mix design shall be provided by the Contractor.

### 2.03 SOURCE QUALITY CONTROL

A. The Engineer will perform testing concrete ingredients at their source of supply using an Owner-hired independent testing laboratory.

### PART 3 - EXECUTION

#### 3.01 PREPARATION

A. Inspect forms, earth bearing surfaces, reinforcement, and embedded items, and obtain the Engineer’s written approval before placing concrete.

B. Verify that substrates are in suitable condition to receive the work of this Section. Correct unsuitable conditions prior to proceeding.

C. Earth bottoms or bearing surfaces for footings and slabs shall be dampened but not saturated or muddied just prior to placing concrete.

#### 3.02 PLACEMENT

A. Convey and place concrete in compliance with the applicable requirements of ACI 301, ACI 302.1R, ACI 304R, and ACI 318.

B. Place no concrete until reinforcing is fastened in place and forms are complete. Place no concrete before work that is to be embedded has been correctly set and secured. Do not disturb reinforcing or other materials that have been set in place.

C. Conform to the requirements of ACI 318. Remove debris, mud and water from surfaces to receive concrete. Clean surfaces of forms and embedded items of all mortar, grout and deleterious materials before placing concrete. Place concrete in dry formwork and prevent water from entering or lying in formwork where concrete is being placed or is setting.
D. Place concrete immediately after mixing. Do not use concrete after it has begun to stiffen. Do not retemper concrete by adding water in the field. If chuting is used, prevent segregation. Concrete at time of placing shall have 4 inches slump maximum, unless otherwise specified or approved with mix design, and temperature of 50 to 90 degrees F. Concrete with temperature exceeding 90°F at time of placement will be rejected and shall be removed from the job site.

E. Minimum Concrete Cover (Unless otherwise indicated on the Contract Drawings):
   1. Concrete deposited against ground: 3 inches
   2. Formed surfaces exposed to weather: 2 inches
   3. Slab-on-grade with one layer of reinforcement: Centered

F. Conform to ACI 305R and 306.1 for placement of concrete in hot and cold weather, respectively.

G. Transfer concrete from mixer to point of placement as rapidly as practical preventing formation of cold joints. Use equipment and methods that permit rapid placing of concrete of the required consistency and prevent segregation.
   1. Convey concrete with conveyors, pipes, chutes, or spouts to a point not more than 3 feet from its final position.
   2. Do not change material proportions or consistency of the concrete to accommodate mixing and placing.
   3. Use no pipes, chutes or other equipment made of aluminum.

H. Regulate air entrainment and slump within specified limits.

I. Deposit concrete vertically in forms as nearly as practical in its final position, in approximately horizontal layers.

J. Pumping: Concrete may be placed by pumping where approved by the Engineer.
   1. Use equipment for pumping of such size and design as to ensure a practically continuous flow of concrete at the delivery end without separation of materials. Pump shall be piston or squeeze pressure type. Pipeline shall be steel pipe or heavy duty flexible hose. Inside diameter of the pipe shall be at least three times the maximum size of the coarse aggregate. Distance to be pumped shall not exceed the limits recommended by pump manufacturer. Supply concrete continuously to the pump. When pumping is completed, eject the concrete remaining in the pipeline without contaminating the concrete in place. After each operation, thoroughly clean equipment. Waste flushing water outside the forms in compliance with storm water pollution prevention requirements specified in Section 01560, Temporary Controls.
   2. Do not pump concrete through aluminum pipes.
3. Provide full-time inspection of all pumping operations by a recognized testing laboratory approved by the Engineer.

K. Avoid formation of laitance and accumulation of excessive water on surface of concrete as it is deposited. Remove accumulated water before placing additional concrete.

### 3.03 CONSTRUCTION JOINTS

A. Construction joints will be permitted only where indicated or approved by the Engineer.

B. Make construction joints straight and as inconspicuous as possible, and in exact vertical and horizontal alignment with the structure, as the case may be.

C. Locate joints which are not indicated so that the strength of the structure is not impaired and where shown on approved shop drawings.

D. Provide and prepare construction joints and install waterstops in accordance with the applicable requirements of ACI 301 and ACI 304R, and as specified in Section 03100, Concrete Forming.

E. Use approved key, at least 1-1/2 inches in depth, at joints unless otherwise indicated or approved by the Engineer.

F. Thoroughly clean the surface of the concrete at construction joints and remove laitance, loose or defective concrete, coatings, sand, sealing compound and other foreign material. Prepare surfaces of joints by sandblasting or other approved methods to remove laitance and expose aggregate uniformly.

G. Immediately before new concrete is placed, wet the joint surfaces and remove standing water. To allow for shrinkage, do not place new concrete against the hardened concrete side of a construction joint for a minimum of 72 hours.

H. Ensure that reinforcement is continuous across construction joints.

I. Where bonding of the joint is required, provide bonding agent.

J. Retighten forms and dampen concrete surfaces before concrete placing is continued.

K. Allow at least 72 hours to elapse before continuing concrete placement at a construction joint. Approval for accelerating the minimum time elapsing between adjacent placements will be based on tests and methods which confirm that a minimum moisture loss at a relatively constant temperature will be maintained for the period as necessary to control the heat of hydration and hardening of concrete, and to prevent shrinkage and thermal cracking.
3.04 CONSOLIDATION AND FINISHING

A. Thoroughly work concrete into all corners and around all embedded items and into corners and shapes of formwork, leaving no excessive voids in the concrete or honeycombed surfaces.

B. Consolidate concrete with a mechanical vibrator of type and size acceptable to the Engineer. Vibrators shall be operated in such a manner as to reach all concrete areas, but minimize the amount of contact with reinforcing steel and formwork.

C. All concrete shall be fully consolidated within 15 minutes of placement.

D. Obtain a uniform surface by floating as necessary. Concrete surface shall be within 1/4 inch laterally and 1/8 inch vertically from specified line and grade, except where stricter tolerances are indicated.

E. Apply a uniform broomed finish to the concrete surface unless indicated otherwise. Broom marks shall not exceed 1/8 inch in depth.

F. Tool all edges with a 2-inch wide, 1/4-inch radius rounded edger.

G. Refer to Section 03170, Concrete Finishing, for additional finishing requirements.

3.05 CURING AND PROTECTION

A. Curing of concrete shall conform to applicable requirements of ACI 301 and ACI 308, except that the curing duration shall be a minimum period of ten days. Curing with earth, sand, sawdust, straw, and hay will not be permitted.

B. Keep concrete in a moist condition from the time it is placed until it has cured for at least ten days. Keep forms damp and cool until removal of forms.

C. Immediately upon removal of forms, exposed concrete surfaces shall be kept moist by applying an approved curing compound or by covering with damp curing materials as specified in Section 03170, Concrete Finishing.

D. Do not permit concrete to dry during the curing period because of finishing operations.

E. Protect fresh concrete from hot sun, drying winds, rain, damage, or soiling. Fog spray freshly placed slabs after bleed water dissipates and after finishing operations commence. Allow no slabs to become dry at any time until finishing operations are complete.

F. Finishing and curing of slabs are specified in Section 03170, Concrete Finishing.

G. Protect concrete from injurious action of the elements and defacement of any kind. Protect exposed concrete corners from traffic or use which will damage them in any way.
H. Protect concrete during the curing period from mechanical and physical stresses which may be caused by heavy equipment movement, subjecting the concrete to load stress, load shock, or excessive vibration.

I. Fog Spray: Keep the entire surface of concrete damp by applying water with a nozzle that so atomizes the flow that a mist and not a spray is formed, until the surface of the concrete is covered with a curing medium. The moisture from the nozzle shall not be applied under pressure directly upon the concrete and shall not be allowed to accumulate on the concrete in a quantity sufficient to cause a flow or wash the surface.

J. Maintain a minimum temperature of 50 degrees F in the concrete for not less than 6 days for concrete subject to loads.

3.06 GROUT

A. Surface Preparation:

1. Concrete surfaces to receive grout shall be prepared by chipping, water blasting, or other accepted methods to remove defective concrete, laitance, dirt, oil, grease, and other foreign matter to achieve sound, clean concrete surfaces. Lightly roughen concrete for bond, but not to interfere with proper placement of grout.

2. Cementitious Grout: Saturate concrete surfaces with clean water for 24 hours prior to grouting, and remove excess water immediately before grouting.

3. Epoxy Grout: Apply only to a clean, dry, roughened, sound concrete surface.

B. Mixing:

1. Mix grout ingredients for both cementitious and epoxy grout in accordance with the respective manufacturer’s mixing instructions and recommendations. Mix grout materials in proper mechanical mixers.

2. Mix grout as close to work area as possible.

C. Placing:

1. Cementitious Grout:

   a. Place in accordance with manufacturer’s instructions.

   b. Completely fill all spaces and cavities below the bottom of baseplates.

   c. Provide forms where baseplates and bedplates do not confine grout.
d. Where exposed to view, finish grout edges smooth. Taper edges at an angle of 60 degrees when measured from the horizontal, or as indicated on the Contract Drawings.

e. Protect against rapid moisture loss by covering with wet rags or polyethylene sheets.

f. Wet cure grout for seven days, minimum.

2. Epoxy Grout:

   a. Place in accordance with manufacturer’s instructions.

   b. Completely fill all spaces and cavities around dowels and anchors without voids.

   c. Obtain manufacturer’s field technical assistance as required to ensure proper placement.

   d. Cure grout as recommended by the manufacturer.

3.07 FIELD QUALITY CONTROL

A. The Engineer will perform field testing listed herein by use of an Owner-hired independent testing laboratory. The Engineer will determine test locations. Test results will be made available to the Contractor. Provide assistance to the testing laboratory in taking samples upon the Engineer’s request.

1. At least one set of three cylinders made in accordance with ASTM C31 and cured under laboratory conditions for each day of placing concrete or grout.

2. At least one slump testing in accordance with ASTM C143 and air content test in accordance with ASTM C138, C173, or C231 made for each day of placing concrete or grout.

3. The three concrete cylinders will be broken after 28 days to determine the compressive strength of the concrete. Compressive strength will be tested in accordance with ASTM C39.

4. The one grout cylinder will be broken after 7 days, and two grout cylinders will be broken after 28 days to determine the compressive strength of the grout. Compressive strength will be tested in accordance with ASTM C39.

B. If the average compressive strength of any set of three concrete cylinders, or any set of two grout cylinders broken at 28 days, does not achieve the specified amount, the Engineer may require the Contractor to do one or more of the following, at the Contractor’s expense:

1. Additional field testing by coring or impact hammer to determine if in-place compressive strength meets specified requirement. The Contractor shall repair all core holes as approved by the Engineer.
2. Removal and replacement of work.
3. Other procedures determined by the Engineer.

END OF SECTION
SECTION 03400
PRECAST CONCRETE STRUCTURES

PART 1 - GENERAL

1.01 DESCRIPTION

A. Section includes specifications for precast concrete structures, including fabrication and erection.

1.02 REFERENCE STANDARDS

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

1. A123 Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
2. A153 Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
3. C31 Making and Curing Concrete Test Specimens in the Field
4. C39 Compressive Strength of Cylindrical Concrete Specimens
5. C260 Specification for Air-Entraining Admixtures for Concrete
6. C494 Specification for Chemical Admixtures for Concrete
7. C618 Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete

B. American Welding Society (AWS):

1. D1.1 Structural Welding Code – Steel
2. D1.4 Structural Welding Code – Reinforcing Steel

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

1. Section 51 Concrete Structures

D. Precast/Prestressed Concrete Institute (PCI):

1. MNL 116 Manual for Quality Control for Plants and Production of Structural Precast Concrete Products
2. MNL 120 Design Handbook – Precast and Prestressed Concrete
1.03 SYSTEM DESCRIPTION

A. Design precast components in accordance with PCI MNL 120.

B. Fabricate and erect precast concrete units in accordance with PCI MNL-116, as indicated on the Contract Drawings and as specified herein.

1.04 SUBMITTALS

A. Shop Drawings: Submit shop drawings prepared by an experienced professional detailer showing complete information for fabrication and installation of precast concrete units. Indicate unit dimensions and cross-section; fabrication tolerances; location, size, and type of reinforcement, including special reinforcement; and lifting devices necessary for handling and erection.

1. Show layout, dimensions, and identification of each precast unit corresponding to sequence and procedure of installation.

2. Indicate welded connections by AWS standard symbols. Detail inserts, connections, and joints, including accessories and construction at openings in precast units.

3. Quantities, dimensions, and locations of sleeves, anchors, brackets, inserts, reglets, accessories, and methods of securing same in forms.

4. Casting, consolidating, and finishing procedures.

5. Include setting diagrams and instructions as required for installation.

B. Submit concrete mix designs as specified under Section 03300, Cast-In-Place Concrete.

C. Comply with the submittal requirements specified in Section 03200, Concrete Reinforcing, and Section 03300, Cast-In-Place Concrete.

D. Product Data: Submit manufacturer's product data of manufactured products and accessories. Include manufacturer's detailed drawings and dimensions when applicable.

E. Quality Assurance Submittals:

1. Submit evidence of current plant certification under the PCI Plant Certification Program.

2. Submit qualifications of fabricator including a list of three successfully completed precast jobs of similar type and size to the project. Include a detailed description of the fabricated structure, project name, location, general contractor, and engineer.

3. For welders, furnish welding certificates or affidavits attesting to the welders' qualifications to perform the indicated and specified welding.
Welders shall be prequalified in accordance with AWS D1.1 or AWS D1.4, as applicable to the work.

### 1.05 QUALIFICATIONS OF THE FABRICATOR

A. Plant shall be PCI certified under the PCI Plant Certification Program or equivalent and regularly engaged in design and construction of structural precast concrete with a minimum of five (5) years experience. PCI Certification shall be in a product group and category appropriate to the work.

### 1.06 DELIVERY, STORAGE, AND HANDLING

A. Transport, handle, and store precast units in a manner that will prevent damage to the units. Units shall be handled such that the points of the support and direction of the reactions with respect to the unit are approximately the same during transportation and storage as when the unit is in the final position.

B. Store units in a manner that will prevent cracking, distortion, staining, or other damage. Units shall be stored above ground on skids or other supports to keep items free of dirt and other foreign debris.

C. Units damaged by improper storage or handling shall be replaced or repaired to the satisfaction of the Engineer.

### PART 2 - PRODUCTS

#### 2.01 MATERIALS

A. Precast concrete members shall conform to the provisions in Caltrans Standard Specifications, Section 51, “Concrete Structures”, and as specified herein.

B. Reinforcement: Comply with applicable requirements of Section 03200, Concrete Reinforcing.

C. Concrete: Comply with the applicable requirements of Section 03300, Cast-In-Place Concrete, and the following:

1. Flyash meeting the requirements of ASTM C618, Type C, may be used as a cement replacement only with the approval of the Engineer.
   a. Type F may be used to modify potentially reactive aggregates
   b. Flyash may replace up to 15 percent, by weight, of the cement

2. Admixtures
   a. All admixtures must be from the same manufacturer.
   b. Air-entraining admixtures shall conform to ASTM C260 and shall be used to produce 6 to 8 percent entrained air in the concrete after all admixtures have been incorporated.
   c. Water reducing admixtures meeting the requirements of ASTM
C494, Type A, may be used only with the approval of the Engineer.

d. Admixtures containing chlorides and sulfides are not acceptable.

2. Maximum total chloride ion content contributed from all ingredients of concrete including water, aggregates, cement, and admixtures measured as a weight percent of cement shall not exceed 0.06.

2.02 FABRICATION

A. Field verify dimensions shown on the Contract Drawings prior to fabrication of any precast concrete structure. Notify the Engineer of any differences between field measurements and those shown on the Contract Drawings.

B. The manufacture, quality, dimensional, and erection tolerances of all precast units shall be in accordance with PCI MNL 116.

C. Forms shall be accurately constructed to produce units to dimension, shape, configuration, and profile indicated. When not otherwise indicated, construct forms to produce smooth concrete.

D. Anchors, Lift Devices, and Accessories: Provide concrete inserts, reglets, anchors, brackets, and fasteners as indicated or required for fabrication and installation work. All items shall be zinc-coated or galvanized in accordance with ASTM A153 or ASTM A123, as applicable. Contractor shall select the lift devices, and shall be responsible for their performance and for any damage resulting from the use of faulty or inferior devices. Lift devices shall not be visible on exposed faces of precast members. Provide a minimum four for each unit.

E. Concrete reinforcement, lifting reinforcement, and concrete inserts and anchorage devices shall be placed and secured against movement as required.

F. Concrete shall be placed and consolidated to shape, configuration, and dimensions indicated.

G. Identification: Identify each precast unit, in a semi-permanent manner, at the precasting yard with respect to the final location. Locate such identification and make it of such material as to withstand wear during shipping and damage from the elements for a period of not less than one year. Protect and preserve identification marks and restore any identification which becomes damaged or partially obliterated.

1. The Engineer reserves the right to reject any unit, and require replacement, if the identification becomes obliterated.

H. Repair or replace any unit which does not conform to the dimensions or structural standards shown on the Contract Drawings or specified herein, and which is not suitable for use as determined by the Engineer.
2.03 FABRICATION TOLERANCES

A. Fabricate precast units conforming to the maximum dimensional tolerances listed in the PCI Standards for precast concrete structures. Units shall be stored in such a way as to permit the Inspector access to all sides at all times.

2.04 SOURCE QUALITY CONTROL

A. The Engineer will perform an inspection of precast concrete structures during the fabrication process at the manufacturing plant.

B. The Contractor-employed independent testing laboratory or agency shall perform such inspections and tests as required to verify compliance with these Specifications, including the following testing: Concrete shall be tested for compressive strength specified in Section 03300, Cast-in-Place Concrete. A set of seven cylinders shall be prepared for every ten precast units, or fraction thereof, cast in any one day. Two cylinders shall be tested at 3 days, two cylinders at 7 days, two cylinders at 28 days, and one cylinder shall be retained for further testing as may be required. Cylinders shall be prepared and moist cured in accordance with ASTM C31, and tested in accordance with ASTM C39.

PART 3 - EXECUTION

3.01 PREPARATION

A. Verify acceptability and location of supports to receive precast concrete structures. Examine all parts of the supporting structure and the conditions under which the precast units are to be erected and installed. Check bearing surfaces to determine that they are level and uniform.

3.02 INSTALLATION

A. Perform excavation and backfill operations in accordance with Section 02300, Earthwork.

B. Install precast concrete structures, including precast concrete field joints, in conformance with Caltrans Standard Specifications, Section 51-1.115, “Precast Members,” as specified herein, and to the stages shown on the Contract Drawings.

END OF SECTION
SECTION 03450
PRECAST ARCHITECTURAL CONCRETE

PART 1 - GENERAL

1.01 DESCRIPTION

A. Section includes specifications for precast architectural concrete items, including mini-high platforms.

1.02 REFERENCE STANDARDS

A. American Concrete Institute (ACI):
   1. 318 Building Code Requirements for Reinforced Concrete

B. American Society for Testing and Materials (ASTM International):
   1. A36 Specification for Carbon Structural Steel
   2. A82 Specification for Steel Wire, Plain, for Concrete Reinforcement
   3. A153 Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
   4. A185 Specification for Steel Welded Wire Reinforcement, Plain, for Concrete
   5. A283 Specification for Low and Intermediate Tensile Strength Carbon Steel Plates
   6. A307 Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
   7. A497 Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete
   8. A615 Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
   9. A706 Specification for Low-Alloy Steel Deformed Bars for Concrete Reinforcement
   10. A767 Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement
   11. A775 Specification for Epoxy-Coated Steel Reinforcing Bars
   12. C33 Specification for Concrete Aggregates
   13. C39 Compressive Strength of Cylindrical Concrete Specimens
15. C260 Specification for Air-Entraining Admixtures for Concrete
16. C494 Specification for Chemical Admixtures for Concrete
17. C642 Test Method for Density, Absorption, and Voids in Hardened Concrete
18. C979 Specification for Pigments for Integrally Colored Concrete

C. American Welding Society (AWS):
   1. D1.1 Structural Welding Code - Steel
   2. D1.4 Structural Welding Code – Reinforcing Steel
   3. D1.6 Structural Welding Code – Stainless Steel

D. Concrete Reinforcing Steel Institute (CRSI):
   1. Manual of Standard Practice

E. Precast/Prestressed Concrete Institute (PCI):
   1. MNL 117 Manual for Quality Control for Plants and Production of Architectural Precast Concrete Products
   2. MNL 120 Design Handbook – Precast and Prestressed Concrete

1.03 DESIGN REQUIREMENTS

A. Precast concrete units shall be reinforced with new billet steel reinforcing bars, as necessary for safe handling, setting and structural stress, and the size of the reinforcing shall be specified with a minimum area of steel equal to one quarter of one percent of the cross section area. If the surfaces are to be exposed to the weather, the reinforcement shall be galvanized or epoxy coated when covered with less than 2 inches of material for bars larger than 5/8 inch and 1-1/2 inches for bars 5/8 inch or smaller. The material covering in all cases shall be at least twice the diameter of the bars. Very small non-structural pieces, such as 8 x 8 x 4 inch, may be made without reinforcing if approved by the Engineer.

B. Reinforcing shall comply with CRSI Manual of Standard Practice.

1.04 SUBMITTALS

A. Mix designs: Submit mix designs along with laboratory test reports, less than 6 months old, performed by a qualified testing agency using the same mix design as proposed for the work showing absorption and compressive strengths
meeting the requirements of these specifications. Include names and brands of materials, proportions, slump, strength, and gradation of aggregates.

B. Shop Drawings: Submit shop drawings prepared by an experienced professional detailer showing complete information for fabrication and installation of precast concrete units. Indicate unit dimensions and cross-section; fabrication tolerances; location, size, and type of reinforcement, including special reinforcement; and lifting devices necessary for handling and erection.

1. Show layout, dimensions, and identification of each precast unit corresponding to sequence and procedure of installation.

2. Indicate welded connections by AWS standard symbols. Detail inserts, connections, and joints, including accessories and construction at openings in precast units.

3. Show caulked joints, including expansion joints ("soft" type) and grouted joints ("rigid" type).

4. Show location and details of anchorage devices to be embedded in other construction.

5. Indicate the specified protective finishes for metal items including connectors.

6. Include setting diagrams and instructions as required for installation.

C. Samples: Minimum size 6 x 6 x 2 inches to illustrate the quality, color, and specified surface finish texture.

D. Submit samples or catalog cuts of cast-in gaskets, anchors, and other attachments and accessories.

E. Submit qualifications of fabricator including a list of five successfully completed precast jobs at least five years old. Include a detailed description of the fabricated item, project name, location, general contractor, and architect or engineer.

1.05 QUALITY ASSURANCE

A. Qualifications of Fabricator:

1. Fabricator of precast concrete products shall be an active and approved participant in the PCI Plant Certification Program.

2. Precast concrete work shall be produced in a plant or production facility by a fabricator who has been regularly and continuously engaged in the manufacture of architectural precast concrete product for a minimum of five (5) years.

B. Applicable standards for inspection and quality control shall be PCI MNL 117 and PCI MNL 120.
C. Precast units that are suspended from the structure or carry weight over openings shall be detailed under the supervision of a qualified professional engineer registered in the State of California if the structural design of the piece is not shown on the Contract Drawings.

D. Installer of precast work shall have a minimum of 3 years successful experience in erection of architectural precast concrete units similar to units required for the Work.

E. Welding shall conform to the requirements in AWS D1.1, AWS D1.4, and AWS D1.6, as applicable to the work.

1.06 DELIVERY, STORAGE, AND HANDLING.

A. Store units at project site to prevent cracking, distortion, warping, staining, or other physical damage and so that markings are visible. Lift and support units only at designated lifting or supporting points as shown on approved shop drawings.

PART 2 – PRODUCTS

2.01 REINFORCEMENT

A. Reinforcing Bars: ASTM A615, or ASTM A706, Grade 60, deformed. Reinforcing bars conforming to ASTM A706 shall be used when welding bars.

B. Epoxy-Coated Reinforcing Bars: ASTM A775.

C. Galvanized Reinforcing Bars: ASTM A767, Class II (2.0 oz. zinc psf), hot-dip galvanized after fabrication and bending.

D. Steel Wire: ASTM A82, plain, cold-drawn, steel.


G. Supports for Reinforcement: Provide supports for reinforcement including bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing.

1. For exposed-to-view concrete surfaces, where legs of supports are in contact with forms, provide supports with legs that are plastic protected (CRSI, Class I) or stainless steel protected (CRSI, Class 2).

2.02 CONCRETE MATERIALS

A. Use only one brand, type, and source of supply for each type of cement, aggregates, pigments, and other materials affecting color throughout the work.
B. Portland Cement: ASTM C150, Type I or Type III. White cement, gray cement, or a blend of white and gray cement may be used as long as the color is achieved as approved by the Engineer.

C. Coarse Aggregate: ASTM C33; hard, durable, selected, and graded; free of material that causes staining or reacting with cement. Color shall be white. Darker aggregates may be used as long as the color is achieved as approved by the Engineer.

D. Fine Aggregate: ASTM C33; hard, durable, selected, and graded; free of material that causes staining or reacting with cement. Color shall be white. Darker aggregates may be used as long as the color is achieved as approved by the Engineer.

E. Pigments: ASTM C979; Inorganic, nonfading, resistant to lime and other alkalis, and containing no carbon black. Provide ready-to-use, pure, and concentrated pigment material specially processed for mixing into concrete. Pigments shall not to exceed 10 percent of the cement weight.

F. Water: Drinkable, clean, and free of injurious amounts of oil, acid, alkali, salts, organic material, and any other substances that may be harmful to concrete or embedded steel.

G. Air-Entraining Admixture: ASTM C260

H. Water-Reducing, Retarding, or Accelerating Admixtures: ASTM C494, type as selected by fabricator. Admixtures containing chlorides and sulfides are not acceptable.

2.03 CONNECTION MATERIALS

A. Steel Plates: Structural quality, hot-rolled carbon steel, ASTM A283, Grade C

B. Steel Shapes: ASTM A36

C. Stainless Steel Shapes: AISI Type 302/304

D. Anchor Bolts: ASTM A307, low-carbon steel bolts, regular hexagon nuts and carbon steel washers

E. Electrodes for Welding:
   1. Steel plates and shapes: E70 meeting the requirements of AWS D1.1, and as applicable to plates conforming to ASTM A283
   2. Reinforcing bars: E90 meeting the requirements of AWS D1.4
   3. Stainless steel: E70 meeting the requirements of AWS D1.6

F. Cast-In Items: Provide reglets, slots, holes, inserts, and other accessories in units to receive dowels, reglets, flashings, anchors and other similar work as indicated.
G. Anchorages: Provide loose steel plates, clip angles, seat angles, anchors, dowels, cramps, hangers, and other miscellaneous loose steel shapes, necessary for securing precast units to supporting and adjacent members.

H. Finish of Steel Cast-In Items: Items exposed to weather shall be hot-dip galvanized after fabrication in accordance with ASTM A153. Items not exposed to weather shall be painted with one coat of rust-inhibitive primer. Threaded inserts cast into precast units shall be hot-dip galvanized, electrogalvanized, or cadmium plated.

2.04 MISCELLANEOUS MATERIALS

A. Cast-In Items: Provide waterstops and similar accessories as indicated.

2.05 MIX DESIGN

A. Prepare design mix for the type of concrete required. Unless otherwise noted, all architectural precast shall be the same color and of the same mix design.

B. Obtain design mixes from an independent testing facility or qualified precast manufacturing plant personnel, at precast fabricator's option.

C. Proportion mixes by either laboratory trial batch or field experience methods, using materials to be employed on the project for each type of concrete required, complying with ACI 318.

D. Mix Properties: Standard-weight concrete consisting of specified Portland cement, aggregates, pigments, admixtures, and water to produce the following properties.

1. Compressive Strength: 6000 psi minimum at 28 days. Tests shall be performed by a professional testing laboratory using 6” x 12” cylinders per ASTM C39.

2. Total Air Content: Minimum 4 percent, maximum 7 percent

3. Water Absorption: Not to exceed 5 percent by weight when tested per ASTM C642.

4. Color: Except as otherwise indicated, integral custom colored mix to match a colored sample provided by the Engineer.

E. Adjustment to Concrete Mixes: Mix design adjustments may be requested when characteristics of materials, job conditions, weather, test results, or other circumstances warrant. Submit laboratory test data for revised mix designs and strength results to the Engineer and obtain Engineer’s acceptance before using in the work.

F. Admixtures: Use air-entraining admixture in strict compliance with admixture manufacturer's directions. Other admixtures to increase cement dispersion or provide increased workability for low-slump concrete may be used subject to
Engineer’s acceptance. Use amounts as recommended by admixture manufacturer for climatic conditions prevailing at time of casting. Adjust quantities of admixtures as required to maintain quality control.

2.06 FABRICATION

A. General: Fabricate precast concrete units complying with manufacturing and testing procedures, quality control recommendations, and dimensional tolerances as described herein, unless otherwise indicated.

B. Provide forms and, where required, form-facing materials of metal, plastic, wood, or other acceptable material that is nonreactive with concrete and will produce required finish surfaces per the approved sample. Accurately construct forms mortar-tight and of sufficient strength to withstand pressures due to concrete placing operations, and temperature changes. Maintain form work to provide completed precast concrete trim units of shapes, lines, and dimensions indicated, within specified fabrication tolerances.

C. Dimensional Tolerances of Finished Units:

1. Overall height and width measured at face adjacent to mold at time of casting: Plus or minus 1/8 inch.

2. Angular deviation of plane of side mold: 1/32 inch per 3 inches depth or 1/16 inch total, whichever is greater.

3. Out of square (difference in length of two diagonal measurements): 1/8 inch per 6 feet or 1/4 inch total, whichever is greater.

4. Thickness: Minus 1/8 inch, plus 1/4 inch

5. Tolerances of other dimensions not otherwise indicated: Numerically greater of plus or minus 1/16 inch per 10 feet, or plus or minus 1/8 inch.

6. Other tolerances per PCI MNL-117

D. Position Tolerance: For cast-in items measured from datum line locations as shown on approved shop drawings:

1. Anchors and inserts: Within 3/8 inch of centerline location shown on shop drawings.

2. Blockouts and reinforcements: Within 1/4 inch of position shown on shop drawings, where such positions have structural implications or affect concrete cover; otherwise within plus or minus 1/2 inch.

E. Fabricate units straight, smooth, and true to size and shape, with exposed edges and corners formed or stoned to a minimum radius unless otherwise indicated.

1. Precast trim units that are cracked, broken, spalled, stained, or exceeding the specified manufacturing tolerances will not be acceptable.
F. Curing: Cure units in a warm, moist, totally enclosed curing room for a minimum of 20 hours.

G. Surface Finish: Remove all surface cement paste by means of acid etching or lightly sandblasting to provide a smooth, dense, fine-grained texture with no streaks or blotches. Texture and quality of finish shall match approved sample when viewed in direct daylight at a 10 foot distance.

H. Color: The color shall be match approved sample when viewed in direct daylight at a 10 foot distance. Color variation between pieces shall be minimal as determined by the Engineer.

2.07 SOURCE QUALITY CONTROL

A. Testing: Test specimens shall be prepared by an ACI certified Grade 1 Field Testing Technician. Tests shall be performed by a certified testing laboratory hired by the Contractor. Keep test results on file for at least two years and submit to the Engineer upon request.

1. Perform one set of 6 inches x 12 inches cylinder tests for every 500 cubic feet of concrete placed. Perform at least one set of cylinder tests for work that requires more than 25 cubic feet of concrete but less than 500 cubic feet.

2. Perform one absorption test for every 500 cubic feet of concrete placed. Perform at least one absorption test for work that requires more than 25 cubic feet of concrete but less than 500 cubic feet.

PART 3 – EXECUTION

3.01 INSTALLATION

A. General: Deliver anchorage items to be embedded in other construction before start of such work.

B. Do not install precast units until supporting concrete has attained minimum allowable design compressive strength.

C. Do not install any precast units that have any defects that exceed the acceptable PCI MNL-117 tolerances for dimensions and color if installation would result in unsatisfactory performance or appearance as determined by the Engineer.

D. Install precast concrete members plumb, level, and in alignment in accordance with PCI MNL-117 erection tolerances. Utilize fabricator provided templates. Provide temporary supports and bracing as required to maintain position, stability, and alignment as members are being permanently connected.

1. Maintain horizontal and vertical joint alignment and uniform joint width as erection progresses.

E. Accessories: Install clips, hangers, and other accessories required for erection of precast units to supporting members and backup materials.
F. Anchor units in final position by bolting, welding, grouting, or as otherwise indicated on the Contract Documents. Remove temporary shims, wedges, and spacers as soon as possible after anchoring and grouting are completed.

1. At bolted connections use lock washers or other acceptable means to prevent loosening of nuts.

2. At welded connections apply rust-inhibitive coating on damaged areas, same as shop-applied material. Use galvanizing repair coating on galvanized surfaces.

G. Before pointing and caulking, scrub face of precast with a fiber brush, using mild detergent and water and then thoroughly rinse with clean running water. Remove any mortar on the face of the precast. Do not use acids or prepared cleaners without the approval of the precast fabricator.

3.02 PROTECTION AND REPAIR

A. Protect the precast units from discoloration and staining when washing down the surrounding masonry by covering the precast units with plastic sheeting and/or by thoroughly soaking them with clear water so they will not absorb any of the dirty washdown water that may run onto them. If dirty washdown water gets on the precast, hose it off immediately with clear water.

B. Repair or replace chipped or damaged precast items to the satisfaction of the Engineer. Repair of chipped or damaged precast shall be done only by mechanics skilled in this class of work, with materials and instructions furnished by the fabricator.

C. Replace chipped or damaged precast units that cannot be repaired.

END OF SECTION
PART 1 - GENERAL

1.01 DESCRIPTION

A. Section includes specifications for metal fabrications, including minimum requirements for fabricator, and galvanizing.

1.02 REFERENCE STANDARDS

A. ASTM International (ASTM):

1. A27 Specification for Steel Castings, Carbon, for General Application
2. A36 Specification for Carbon Structural Steel
3. A48 Specification for Gray Iron Castings
4. A53 Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
5. A109 Specification for Steel, Strip, Carbon (0.25 Maximum Percent), Cold-Rolled
7. A153 Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
8. A307 Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile
10. A488 Standard Practice for Steel Castings, Welding, Qualifications of Procedures and Personnel
11. A536 Specifications for Ductile Iron Castings
12. A563 Specification for Carbon and Alloy Steel Nuts
13. A653 Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
15. D6386 Standard Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Painting
16. F436 Specification for Hardened Steel Washers

B. American Welding Society (AWS):
   1. D1.1 Structural Welding Code Steel

C. Department of Defense (DOD):
   1. DOD-P-15328 Primer (Wash), Pretreatment (Formula No. 117 For Metals) (Metric)

D. Federal Specifications (FS):
   1. QQ-F-461 Floor Plate, Steel, Rolled

E. Steel Structures Painting Council (SSPC):
   1. SSPC-SP 1 Solvent Cleaning
   2. SSPC-SP 3 Power Tool Cleaning
   3. SSPC-PA 1 Shop, Field & Maintenance Painting
   4. SSPC-Paint 20 Zinc-Rich Primers (Type I – Inorganic & Type II – Organic)
   5. SSPC-Paint 22 Epoxy-Polyamide Paints (Primers, Intermediate & Topcoats)

1.03 SUBMITTALS

A. Submit shop drawings showing the following:
   1. Sizes, details of fabrication and construction, methods of assembly, locations of hardware, anchors, and accessories, and installation details.
   2. Details for manufacturer’s items or fabricated metalwork.
   3. Field erection details showing cuts, copes, connections, holes, threaded fasteners and welds, both shop and field, by symbols conforming to AWS standards. Indicate net weld lengths.

B. Submit manufacturers’ product data. Include application instructions for galvanizing repair product.

C. Metal Fabricator: Submit a list of projects demonstrating a minimum of 5 years of experience in the custom fabrication and construction of metal fabrications and miscellaneous metalwork.
D. Written verification from the manufacturer that the primer is compatible with the finish coats specified in Section 09900, Paints and Coatings.

1.04 DELIVERABLES

A. Welders' Certificates: Submit certification of personnel employed on the work to satisfy the requirements of Part 4 of AWS D1.1.

1.05 QUALITY ASSURANCE

A. All metal fabrications shall be done by a licensed fabrication shop with a minimum of 5 years of experience in this type of work.

B. Welding including shielded arc process shall conform to the requirements in AWS D1.1 Structural Welding Code

PART 2 - PRODUCTS

2.01 STEEL

A. Plates, Shapes and Bars: ASTM A36, unless otherwise noted

B. Sheet, Commercial Quality, Galvanized: ASTM A653, G90

C. Strip: ASTM A109

D. Pipe: ASTM A53, Grade B, Schedule 40, black or galvanized, as indicated

E. Castings: ASTM A27 or A48, as indicated

F. Ductile Iron: ASTM A536

2.02 FASTENERS

A. Steel Bolts, Anchor Bolts, Nuts, Shear Studs and Threaded Rods: ASTM A 307, ASTM A 563, and ASTM F 436, unless otherwise noted. Bolts and studs, nuts, and washers shall be hot-dip galvanized in accordance with ASTM A 153.

B. High Strength Steel Bolts and Nuts: ASTM A 325, unless otherwise noted.

C. Threaded Inserts: ASTM A 488, unless otherwise noted.

2.03 MISCELLANEOUS MATERIALS

A. Use E7018 low hydrogen electrodes for A36 steel.

B. Primer Pretreatment: DOD-P-15328.

C. Corrosion-Inhibitive Metal Primer: SSPC-Paint 20 or SSPC-Paint 22. Verify compatibility of shop primer and finish coats specified in Section 09900, Paints and Coatings.
2.04 CHECKERED SAFETY PLATE

A. FS QQ-F-461, Class 1, flat black, standard 4-way raised pattern.

2.05 IRON CASTINGS

A. Gray: ASTM A48, Class 35B, unless otherwise noted.

2.06 FABRICATION - GENERAL

A. Fabricate miscellaneous metal items with light structural angles, tees, bars, channels, plates, rods, pipes and other rolled steel shapes, as indicated in the Contract Documents and specified herein.

B. Fabricate work true to shape, size and tolerances as indicated on the Contract Drawings and approved shop drawings; with straight lines, square corners or smooth bends; free from twists, kinks, warps, dents, and other imperfections. Straighten work bent by shearing or punching. There shall be no exposed screws, bolts, and fasteners in the finished work, except as indicated or required.

C. Utilize metal of sufficient thickness and detail assembly and support to provide strength and stiffness sufficient to resist distortion during shipment, handling, installation, and severe service conditions. Exposed edges and ends of metal shall be ground smooth with no sharp edges and with corners slightly rounded. Connections and joints exposed to weather shall be watertight.

D. Form curved work to radii indicated. Furnish bolts, nuts, washers, and other fastening devices required for securing work.

E. For pipe sleeves in concrete construction, provide standard weight, black steel pipe with anchors welded to exterior. Provide sizes as required to accommodate passage of conduits, pipes, ducts and similar items with proper clearance.

F. Fabricate flanges for posts from 3/8-inch minimum thickness plate, and for standoffs from not less than 3/16-inch thickness plate.

G. Metal fabrications shall be prefabricated and preassembled in the factory or shop as far as practicable.

H. Grind off excess metal and make smooth surface welds which will be exposed to view.

2.07 GALVANIZING

A. Steel and ferrous metal items in contact with concrete, on the exterior of buildings, exposed to the weather and moist conditions, and items specifically indicated, shall be galvanized after fabrication. Fabricate items complete or in largest practical sections before galvanizing. Do not field weld fabricated items except where indicated or permitted by the Engineer. Thoroughly clean welded
areas prior to galvanizing. Remove weld spatter, burrs, oil, grease and any other deleterious matter that would interfere with the adherence of the zinc.

B. Hot dip galvanize products after fabrication (including shearing, punching, bending, forming, or welding) in accordance with ASTM A 123.

C. The weight of zinc coating shall conform to the requirements specified under "Weight of Coating" in ASTM A 123, but not be less than 2.0 ounces per square foot of surface area.

D. Shop galvanized metalwork necessitating field welding which in any manner removes original galvanizing shall be restored by field galvanizing repair in accordance with ASTM A 780.

E. Hardware items, and bolts and screws for attachment of galvanized items shall be galvanized in accordance with ASTM A 153.

### 2.08 SHOP FINISHING

A. Nongalvanized Metalwork: Shop paint ferrous metal which is not indicated to be galvanized.

1. After fabrication and immediately before shop painting, power-tool clean ferrous metalwork in accordance with SSPC-SP 3 to remove mill scale, rust, grease, oil, and any other foreign matter. Wire brush welds thoroughly.

2. After power-tool cleaning and just before shop painting, wash ferrous metalwork with solvent to remove dust and residue in accordance with SSPC-SP 1.

3. After cleaning and solvent washing, shop paint ferrous metalwork with one coat of corrosion-inhibitive metal primer in accordance with SSPC-PA 1. Material and application shall conform to SSPC-Paint 20 or SSPC-Paint 22.

B. Galvanized Metalwork:

1. Galvanized metal surfaces indicated to be painted shall be prepared for painting in accordance with ASTM D 6386.

### PART 3 - EXECUTION

### 3.01 INSTALLATION

A. Install metal fabrications with installation accessories furnished by fabricator as required for complete installation.

B. Install in accordance with approved shop drawings, true and horizontal, perpendicular, or at required angle, as the case may be, level and square with angles and edges parallel with related lines of structure.
C. Install threaded rods used as dowels as specified in Section 03200, Concrete Reinforcing.

D. Field welding, where indicated or allowed, shall conform to the requirements for welding as specified in Section 05200, Structural Steel.

E. Keep field joints to a minimum and concealed. Make field joints strong, rigid, watertight and flush with hairline fit. Grind sharp corners smooth.

F. Grind off excess metal and make smooth surface welds which will be exposed to view.

G. Securely grout posts set in sleeves in conformance to grout manufacturer’s instructions. Attach posts not set in sleeves with appropriate fasteners.

H. After installation, damaged prime surfaces shall be prepared as required and touched up with the same primer used for shop primer; leave ready for field painting.

3.02 GALVANIZING REPAIR

A. Galvanized surfaces which have become damaged from welding, handling, or installation shall be repaired immediately after installation with galvanizing repair material in accordance with ASTM A 780.

END OF SECTION
SECTION 05200
STRUCTURAL STEEL

PART 1 – GENERAL

1.01 DESCRIPTION

A. Section includes specifications for structural steel, including steel designated as structural steel on the Contract Drawings.

1.02 REFERENCE STANDARDS

A. American Institute of Steel Construction (AISC):
   1. Quality Certification Program for Fabricators.

B. American Railway Engineering and Maintenance-of Way Association (AREMA):
   1. Manual for Railway Engineering

C. American Society of Nondestructive Testing (ASNT):
   1. SNT-TC-1A Recommended Practice

D. American Society for Testing and Materials (ASTM):
   1. A588 Standard Specification for High-Strength Low-Alloy Structural Steel with 50 ksi Minimum Yield Point to 4 inches Thick
   2. A709 Standard Specification for Carbon and High-Strength Low-Alloy Structural Steel Shapes, Plates, and Bars and Quenched-and-Tempered Alloy Structural Steel Plates for Bridges
   4. E142 Method for Controlling Quality of Radiographic Testing
   5. E164 Practice for Ultrasonic Contact Examination of Weldments
   6. E165 Test Method for Liquid Penetrant Inspection Method
   7. E709 Guide for Magnetic Particle Examination
   8. E1032 Method for Radiographic Examination of Weldments

E. American Welding Society (AWS):
   2. D1.1 Structural Welding Code Steel
   3. D1.5 Bridge Welding Code
4. D10.9 Specification for Qualification of Welding Procedure and Welders for Piping and Tubing

5. QC1 Specification for AWS Certification of Welding Inspectors

F. State of California, Department of Transportation (Caltrans), Standard Specifications (hereafter Standard Specifications)

1. Section 55 Steel Structures

G. Steel Structures Painting Council (SSPC):

1. SP 1 Solvent Cleaning
2. SP 3 Power Tool Cleaning
2. SP 10 Near-White Blast Cleaning
3. SP 11 Power Tool Cleaning to Bare Metal
4. PA 1 Shop, Field & Maintenance Painting
5. Paint 20 Zinc-Rich Primers (Type I – Inorganic & Type II – Organic)
6. Paint 22 Epoxy-Polyamide Paints (Primers, Intermediate & Topcoats)

1.03 SUBMITTALS

A. Submit shop drawings conforming to Caltrans Standard Specifications, Section 55-1.02 Drawings, second paragraph, and AREMA Manual, Section 1.1 of Chapter 15. Shop drawings shall also show the following:

1. Profiles, sizes, spacing, locations, member identity, methods of assembly, locations of hardware, anchors, and accessories, and erection sequence and details of structural members.

2. Cuts, copes, gussets, holes, openings, fasteners, camber, fabrication and erection tolerances, type of finish, weights of members, and critical clearances. Profiles, sizes, spacing, locations, member identity, methods of assembly, locations of hardware, anchors, and accessories, and erection sequence and details of structural members.

3. Details of connections: bolted and welded. Indicate all shop and field bolts and welds.

4. Details of welded connections with symbols conforming to AWS standards. Indicate size, type, and net lengths of each weld.

5. Investigate stresses caused by the proposed erection procedure. Submit drawings showing details of required temporary supports, staying, and bracing. Include descriptive data and design calculations to illustrate the erection, transportation, and handling procedures, including sequence of erecting and transfer of loads if applicable.
B. Product data for primer including written verification from the manufacturer that the primer is compatible with the finish coats specified in Section 09900, Paints and Coatings.

C. Steel Fabricator: Submit a list of projects demonstrating a minimum of 10 years of experience in the fabrication of structural steel, and verification that the fabricator meets the specified AISC Certification program requirements.

D. Steel Erector: Submit a list of projects demonstrating a minimum of 10 years of experience in the erection of structural steel.

E. Welder Qualifications: Submit copies of qualification test records for each welder, welding operator, and tack welder to be employed in the work. Comply with requirements of AWS D1.1. For pipe and tube, comply with requirements of AWS D10.9.

1. Submit welders' identification marks (I.D.) for each welder along with qualifications.

F. Welding Procedure Specifications (WPS): Prior to commencement of welding, submit the procedure specifications that will be used for welding. The WPS shall contain all data indicated in AWS D1.1 Annex IV, and any other information necessary to produce welded joints in compliance with this specification. For procedures other than those prequalified in accordance with AWS D1.1, D1.2, and D1.5, submit a copy of procedure qualification test records in accordance with the qualification requirements of AWS D1.1, AWS D1.2, and AWS D1.5, as applicable. The WPS shall also include the mitigation of corrosion of welds, including heat treatment and chemical compatibility, as applicable.

G. Welding Records and Data:

1. Submit all radiographs upon completion of fabrication.

2. Submit certifications that magnetic particle and dye-penetrant inspections have been satisfactorily completed.

3. Submit records of ultrasonic testing upon completion.

4. If field welding is permitted, submit descriptive data for field welding equipment.

H. Mill Certificates: Submit mill certificates and certified copy of reports for analyses and tests required by referenced ASTM and AWS specifications.

1.04 DELIVERABLES

A. Quality Control Deliverables:

1. Certified Mill Test Reports: Submit certified mill test reports indicating structural strength, and destructive and non-destructive test analyses.

2. Certificates of Compliance: Submit Certificates of Compliance to certify that products meet or exceed specified requirements.
1.05 QUALITY ASSURANCE

A. Calculations substantiating camber, which are submitted with shop drawings in accordance with Caltrans Standard Specifications, Section 55-1.02, and erection procedures shall be prepared, sealed, and signed by a Professional Engineer hired by the Contractor who is currently registered in the State of California.

B. Steel Fabricator:
   1. Minimum of 10 years experience in the fabrication of structural steel, and who participates in the AISC Certification program and is designated an AISC Certified Plant, Category STD.
   2. Additionally, a fabricator involved in the fabrication of structural steel for bridges shall be designated an AISC Certified Plant, Category CBR.

C. Steel Erector:
   1. Minimum of 10 years experience in the erection of structural steel.

D. Qualifications of Welders and Welding Procedures: Welders, welding operators, tack welders, and welding procedures shall be prequalified or qualified in accordance with the following AWS Welding Codes and Standards:
   1. Structural Steel: AWS D1.1, Section 4, Qualification
   2. Steel for Bridges: AWS D1.5, Section 5, Qualification
   3. Stud Welding: AWS D1.1, Section 7.6, Stud Application Qualification Requirements
   4. Pipe and Tube: AWS D10.9

E. Qualifications of Welding Inspector: Welds to be inspected by the Contractor shall be inspected and certified by a Contractor-employed AWS Certified Welding Inspector (CWI), certified in accordance with AWS QC 1.

F. Qualification of Personnel Performing Nondestructive Testing: Personnel performing nondestructive testing, who are Contractor-employed, shall be qualified and certified in accordance with SNT-TC-1A. Only persons certified for NDT Level I and working under a NDT Level II person or persons certified for NDT Level II may perform nondestructive testing.

G. Weldability of Steel: For structural steel requiring impact test qualification, the weldability of the steel and the procedures for welding it shall be established by qualification in accordance with AWS D1.1, Section 4.

H. Qualification of Stud-Connector Manufacturer: Stud shear connector manufacturer shall be qualified in accordance with AWS D1.1, Annex IX, Manufacturers’ Stud Base Qualification Requirements.

I. Stud Welding Standards: For stud welding, comply with applicable requirements of AWS C5.4.
PART 2 - PRODUCTS

2.01 MATERIALS

A. Unless otherwise noted in the Contract Documents, the following shall be used for structural steel members:


5. Shop Primers: SSPC Paint 20 or 22. Verify compatibility of shop primer and finish coats specified in Section 09900, Paints and Coatings.

B. Section 05500, Metal Fabrications: Steel items required in construction of Shelters, except for shelter steel items designated as structural steel on the Contract Drawings.

2.02 FABRICATION

A. Fabricate structural steel in accordance with Caltrans Standard Specifications, Section 55-3, Fabrication, and as specified herein.

B. Fabricate structural steel for railroad bridges in accordance with AREMA Manual, Chapter 15.

C. Shop Assembly: Steel members shall be prefabricated and preassembled in the shop as far as practicable. Continuously seal joined members by continuous welds. Grind all exposed welds smooth.

D. Field Connections: Provide bolts for all field connections except where indicated or permitted by the Engineer.

1. Use high-strength bolts unless indicated or specified otherwise.

2. If structural steel details shown on the Contract Drawings are not compatible with selected erection procedures, submit proposed modifications for review.

E. Field welding, where indicated or permitted by the Engineer, shall be performed as herein specified for shop welding.
2.03  SHOP FINISHING

A.  Interior, Non-Corrosive Applications:

1.  After fabrication and immediately before shop painting, wash structural steel materials with solvent to remove dust and residue in accordance with SSPC-SP 1.

   a.  Structural Steel Materials not Exposed to the Public:  Power-tool cleaned in accordance with SSPC-SP 3 to remove mill scale, rust, grease, oil, and any other foreign matter.

   b.  Structural Steel Materials Exposed to Public View:  Blast cleaned in accordance with SSPC-SP 10 or power-tool cleaned in accordance with SSPC-SP 11 to remove all visible mill scale, rust, grease, oil, and any other foreign matter.

2.  If materials are not painted immediately after cleaning then those materials shall be washed with solvent to remove dust and residue in accordance with SSPC SP 1.

3.  After preparation, shop paint steel materials with one coat of corrosion-inhibitive metal primer in accordance with SSPC PA 1.  Materials and application shall conform to SSPC-Paint 20 or SSPC-Paint 22.

B.  Exterior Applications:

1.  Steelwork to be Exposed to Weather:  Blast cleaned in accordance with SSPC-SP 10, Near White Blast Cleaning, or power-tool cleaned in accordance with SSPC-SP 11, Power Tool Cleaning to Bare Metal.  For new steel bridges, cleaning shall be in accordance with SSPC-SP 10.

2.  After cleaning, solvent wash in accordance with SSPC-SP 1, and shop paint steelwork in accordance with SSPC-PA 1.  Materials and application shall conform to SSPC-Paint 20.  For new steel bridges, only shop-applied Type I – Inorganic Zinc Rich Primers shall be used.

2.04  SHOP WELDING

A.  Perform shop welding as indicated in accordance with the AWS D1.1 and AWS D1.5, as applicable to the work.

B.  Welders shall mark adjacent to completed welds their welder I.D., using metal stamp, metal engraving, keel, paint stick, or other appropriate marking material.

C.  Welding of stud shear connectors shall conform with AWS D1.1, Section 7, Stud Welding, AWS C5.4, and the stud manufacturer’s instructions.

2.05  INSPECTIONS AND TESTS BY THE CONTRACTOR

A.  Visual Inspection:  All welds for structural steel and structural steel for bridges shall be visually examined in accordance with AWS D1.1, Sections 6 and 7.8, as applicable.  Quality of welds and standards of acceptance shall be in accordance with AWS D1.1, Section 6.9.

C. Radiographic Testing: Radiographic testing of welds shall conform with AWS D1.1, Section 6.12 and ASTM E94, ASTM E142, and ASTM E1032, as applicable. Complete joint penetration groove welds shall be tested as follows:

1. 20 percent with thickness equal to or less than 3/4 inch
2. 50 percent with thickness greater than 3/4 inch and equal to or less than 1-1/2 inches
3. 100 percent for thickness greater than 1-1/2 inches

D. Ultrasonic Testing: Ultrasonic testing of welds shall conform with AWS D1.1, Section 6.13, and ASTM E164, as applicable. Complete joint penetration groove welds not accessible for radiographic testing shall, with Engineer’s approval, be subjected to ultrasonic testing. The extent shall be the same as specified for radiographic testing.

E. Magnetic Particle Inspection: Magnetic particle inspection of welds shall conform with ASTM E709. Complete and partial joint penetration groove welds and fillet welds shall be inspected as follows:

1. 25 percent of complete joint penetration groove welds of tee and corner joints.
2. 20 percent of partial joint penetration groove welds and fillet welds.

F. Liquid Penetrant Inspection: Liquid dye penetrant inspection of welds shall conform to ASTM E165. Liquid penetrant inspection shall be used for detecting discontinuities that are open to the surface.

G. Inspections for Bridge Structural Steel Welding: In addition to the inspection requirements specified herin, inspect welding in accordance with AREMA Section 15.3.5.5 including the following non-destructive testing:

1. All full-penetration welds in girder webs and flanges shall be inspected by the radiographic method.
2. All flange to web welds shall be inspected by the ultrasound method.
3. All fillet welds on bearing stiffeners shall be inspected by the ultrasound method.
4. At least 25 percent of all other welds shall be inspected by the ultrasonic or magnetic particle method.
   a. If any defects are found, 100 percent inspection by the ultrasonic or magnetic particle shall be required.
5. Inspection of welded work for Fracture Critical Members shall be in accordance with AREMA Chapter 15.
6. Time delay prior to NDT of weld repairs to groove welds of ASTM A588 or ASTM A709 material over 2 inches in thickness subject to tensile stress, shall be 16 hours minimum.
H. Test Results: Test result information shall be forwarded to the Engineer immediately after test results are available, stating the acceptance or rejection of fabricated components, so that repairs and reinspection or testing may be performed as soon as possible.

I. Repairs: Unacceptable welds shall be repaired in accordance with AWS D1.1, Section 5.26. Repaired or corrected welds shall be reinspected or retested as specified for the original weld.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Erection:

1. Allow for erection loads, and for sufficient temporary bracing to maintain the structure safely plumb and in true alignment until completion of erection and installation of permanent bracing.

2. Do not field cut or alter structural members without prior approval of the Engineer.

3. After erection, prime welds, abrasions, and surfaces not shop primed, except surfaces to be in contact with concrete.

4. Coordinate the installation of structural steel with the installation of miscellaneous metals to minimize the requirement for field cutting, alteration, temporary bracing, and redundant operations during erection.

B. Erection Tolerances: Maximum offset from true alignment shall be 1/4 inch.

3.02 FIELD FINISH

A. Refer to Section 09900, Paints and Coatings, for field finish for work of this Section.

1. After installation or erection of structural steelwork, abraded areas, field bolts, and welds shall be touched up and spot painted with corrosion-inhibitive primer. Field welds shall be thoroughly wire-brushed or disc-sanded prior to touch-up painting.

END OF SECTION
SECTION 05500
PEDESTRIAN EXIT GATES AND GUARDRAIL

PART 1 - GENERAL

1.01 DESCRIPTION

A. Section includes specifications for pedestrian exit gates and guardrailing for installation at at-grade crossings. The locations of this installation include vehicular grade crossings, and pedestrians only at passenger stations crossings and at rail crossings.

B. The proper functioning of the exit gates requires high level of workmanship in fabrication and installation of hinges and gates.

1.02 REFERENCE STANDARDS

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

1. A36 Specification for Carbon Structural Steel
2. A53 Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
3. A123 Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
4. A780 Practice for Repair of Damaged Hot-Dip Galvanized Coatings

B. American Welding Society (AWS):

1. D1.1 Structural Welding Code Steel

1.03 SUBMITTALS

A. Submit shop drawings showing member sizes, details of fabrication and construction, methods of assembly, and installation details. Guardrailing shall allow for slope variation on sidewalk.

B. Submit shop drawings for the fabricator’s hinges and gates.

C. Submit manufacturers product data. Include application instructions for galvanizing repair product.

1.04 DELIVERABLES

A. Welders Certificates: Submit certification of personnel employed on the work to satisfy the requirements of Part 4 of AWS D1.1.
1.05 QUALITY ASSURANCE

A. Welding including shielded arc process shall conform to the requirements in AWS D1.1 Structural Welding Code.

B. All components (hinges, posts, gates, guardrailing) in this Section shall be fabricated in shop for desired quality. Use only well experienced welders and fitters.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Hinges: DOM (Drawn Over Mandrel) steel with minimum yield strength of 60 ksi.

B. Steel Plate and Miscellaneous Items: ASTM A36, except as otherwise indicated on the Contract Drawings.

C. Steel Pipe for posts, gates and guardrailing: Seamless steel pipe, conforming to ASTM A53, Type S, Grade A, standard weight, nominal size as shown on the Contract Drawings.

D. Brackets, Bolts, Threaded Studs, Nuts, Washers and Other Fittings: Galvanized, commercial quality structural steel, except that standard steel pipe fittings may be used where shown on the Contract Drawings. For mounting of signage to the gates: use only SS 316 hardware as shown on the Caltrain Standard Drawing.

E. Mechanical expansion anchors for attaching the railing to supporting concrete members: Concrete anchorage devices as specified in Section 75-1.03, "Miscellaneous Bridge Metal."

F. Non-Shrink Grout: Master Builders "Embeco," Sonneborn Bldg Products, Inc "Ferrolith G," Halemite Manufacturing Company "Por Rok," or Engineer approved equal.

G. Hot Process Field Galvanizing (for repairs): Galv, Galvalloy, Galvweldalloy, or Engineer approved equal.

2.02 FABRICATION

A. Workmanship: Accurately fabricate hinges, gates and posts neat and rigid in shop for desired quality. Set components accurately in position, leveled, squared and aligned. The dimensions and other details are in the Caltrain Standard Drawing or Contract Documents.

B. Mock-up Set: Fabricate in shop a complete mock-up set for Engineer’s approval. Approved set serves as the standard of quality for other sets.

D. Guardrailing: Weld railings, continuous as detailed. Fabricate welded pipe items with flush welded construction throughout, except where sleeve joints or other mechanical joints for field connection or job requirements are necessary.
E. Heat railing and make radius bends to produce uniform curvature without distortion. Shape curved sections on true radius without buckle, dent, kinks or flattened sections. Cope intersections; continuously weld and grind welds smooth. Return rail ends to 1/4 inch clearance and weld plug over open end.

F. Sleeves for Anchoring Railing Posts in Concrete: Galvanized standard pipe sleeves with welded-on bottom plates or 24 gage galvanized sheet metal sleeves with bottoms. Sleeve diameter shall be at least 3 times the outside diameter of the rail posts.

G. Grind off excess metal and make smooth surface welds which will be exposed to view.

2.03 WELDING

A. Use electric shielded arc process conforming to the requirements of AWS D1.1.
   1. Use E7018 low hydrogen electrodes for A36 steel.

2.04 GALVANIZING

A. Fabricate units complete or in largest practical sections before galvanizing. Thoroughly clean welded areas prior to galvanizing. Remove weld spatter, burrs, oil, grease and any other deleterious matter that would interfere with the adherence of the zinc.

B. Hot dip galvanize exterior railing, gates, and attached metal components after fabrication (including shearing, punching, bending, forming, or welding) in accordance with ASTM A123.

C. The weight of zinc coating shall be not less than 2.0 ounces per square foot of surface area.

D. After galvanizing, all elements of the railing shall be free of fins, abrasions, rough or sharp edges and other surface defects and shall not be kinked, twisted or bent. If straightening is necessary, straighten using methods approved by the Engineer. Kinks, twists, or bends in railing elements may be cause for rejection of the railing elements.

2.05 FINISHES

A. Gates, gate posts and hinges and all attached metal components shall be painted in accordance with Section 09900, Paints and Coatings. Color shall be Federal Safety yellow FS 33538.

B. Guardrailing shall be painted in color as specified in the Contract Documents.
PART 3 - EXECUTION

3.01 INSTALLATION

A. Install work straight and plumb with members anchored, secure and fasten together in accurate position, neat, rigid, level, square, straight and plumb.

B. Keep field joints to a minimum and concealed to greatest practical extent. Make field joints strong, rigid, watertight and flush with hairline fit. Ease sharp corners.

C. Securely posts set in sleeves with non-shrink grout in accordance with grout manufacturer’s instructions.

D. Where posts are not set in sleeves, mechanically secure posts to wood or steel surfaces with fasteners as shown on the Contract Drawings or in accordance with approved shop drawings.

E. Repair abraded or damaged galvanized surfaces with hot process field galvanizing in accordance with ASTM A780 and manufacturer’s published instructions.

3.02 SITE TOLERANCES

A. Gates shall swing open freely and close return such that the gate stops meet tightly.

B. Install guardrail posts vertical within a tolerance not to exceed 0.02-foot in 10 feet.

END OF SECTION
SECTION 07150
POLYMERIC SHEET WATERPROOFING

PART 1 - GENERAL

1.01 DESCRIPTION
A. Section includes specifications for polymeric waterproofing membrane on bridge decks, as well as for ballast mat over membrane on bridge decks.

1.02 REFERENCE STANDARDS
A. American Railway Engineering and Association (AREMA):
B. American Society for Testing and Materials (ASTM International):
   1. D146 Test Methods for Sampling and Testing Bitumen-Saturated Felts and Woven Fabrics for Roofing and Waterproofing
   2. D882 Test Method for Tensile Properties of Thin Plastic Sheeting
   4. D4258 Standard Practice for Surface Cleaning Concrete for Coating
   5. D4263 Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method
   7. E154 Test Methods for Water Vapor Retarders Used in Contact with Earth Under Concrete Slabs, on Walls, or as Ground Cover

1.03 SUBMITTALS
A. Product Data: Technical data and general recommendations for types of waterproofing required.
   1. Data for surface primer, flexible flashings, joint cover sheet, and joint and crack sealants, with temperature range for application of waterproofing membrane.
   2. Installation instructions indicating special procedures and perimeter conditions requiring special attention. Include preparation instructions for existing deck surfaces.
B. Shop Drawings: Indicate special joint or termination conditions and conditions of
interface with other materials.

C. Sample:

1. Membrane waterproofing and auxiliary materials mounted on plywood
2. Ballast mat

### 1.04 DELIVERABLES

**A. Certifications of Compliance:**

1. Certification by waterproofing materials manufacturer stating products supplied comply with local VOC and environmental regulations.
2. Certifications by ballast mat materials manufacturer that materials meet specified requirements.

**B. Written statement from manufacturer’s representative that bridge deck is suitable to receive waterproofing.**

**C. Test Reports: From a qualified independent testing agency evidencing compliance of waterproofing with requirements and other physical properties reported by manufacturer based on comprehensive testing of products according to current standard test methods within previous 5 years.**

**D. Field Quality Control Reports.**

### 1.05 QUALITY ASSURANCE

**A. Single Source Responsibility:** Obtain primary waterproofing materials from a single manufacturer to the greatest extent possible. Provide secondary materials recommended by manufacturer of primary materials.

**B. Installer Qualifications:** Firm with minimum of 5 years documented experience showing satisfactory service performance and acceptable to primary waterproofing materials manufacturer.

**C. The suppliers of ballast mat material shall have successfully furnished such material to Class 1 Freight or Commuter Railroads. This does not include transit or light rail.**

**D. Provide services of waterproofing manufacturer’s field representative to observe and approve surface preparation.**

### 1.06 DELIVERY, STORAGE, AND HANDLING

**A. Deliver primary waterproofing materials to steel fabrication shop or job site, as applicable. Manufacturer’s labels shall include the following information:**

1. Product name and description (generic product classification)
2. Batch number under which product was produced
4. National standards with which the product complies

5. Application instructions

B. Store materials in clean, dry, protected location, and away from direct sunlight.

C. Asphaltic panels shall be stored so as to prevent warping and breaking.

1.07 PROJECT CONDITIONS

A. Weather: Proceed with waterproofing and associated work when existing and forecasted conditions permit work to be performed in accordance with manufacturer’s recommendations and warranty requirements.

B. Temperature: Maintain ambient temperatures above 40 degrees F for 24 hours before and during application and until liquid or mastic accessories have cured.

C. Environmental Conditions: Apply waterproofing within range of ambient and substrate temperatures recommended by waterproofing manufacturer. Do not apply waterproofing to a damp or wet substrate. Do not apply waterproofing in rain, fog, or mist.

D. Maintain adequate ventilation during preparation and application of waterproofing materials.

PART 2 - PRODUCTS

2.01 WATERPROOFING SYSTEM

A. Manufacturer: MEL-DEK, Deck Waterproofing System, as manufactured by W. R. Meadows, Inc, or Engineer approved equal. Waterproofing system shall be able to withstand dynamic placement of hot asphalt overlays.

B. Waterproofing membrane shall be composed of a two layer composite sheet consisting of 53 mil polymeric membrane on a shirk-resistant, heavy duty 12 mil polypropylene woven carrier fabric with an overall thickness of 65 mils. Membrane shall conform to the following properties:
<table>
<thead>
<tr>
<th>Test Method</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength, ASTM D 882</td>
<td>90 lbs/in (1.6 kg/mm)</td>
</tr>
<tr>
<td>Warp</td>
<td>90 lbs/in (1.6 kg/mm)</td>
</tr>
<tr>
<td>Fill</td>
<td></td>
</tr>
<tr>
<td>Elongation, ASTM D 882</td>
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<tr>
<td>Polymeric Membrane</td>
<td>410 percent</td>
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<tr>
<td>Fabric, Warp</td>
<td>35 percent</td>
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<tr>
<td>Fabric, Fill</td>
<td>45 percent</td>
</tr>
<tr>
<td>Puncture, ASTM E 154</td>
<td>275 lbs (122 kN)</td>
</tr>
<tr>
<td>Flexibility, ASTM D 146</td>
<td>Pass</td>
</tr>
<tr>
<td>180 degrees Bend, 1/4 inch (6.35mm) mandrel @ -26 degrees F (-32 degrees C)</td>
<td></td>
</tr>
<tr>
<td>Water Vapor Permeance, ASTM E-96, Water Method</td>
<td>0.03 Perms</td>
</tr>
<tr>
<td>Water Absorption, ASTM D 1970</td>
<td>0.06 percent</td>
</tr>
</tbody>
</table>

C. Auxiliary Materials: Furnish auxiliary materials recommended by waterproofing manufacturer for intended use and compatible with waterproofing sheet membrane.

1. Primer: Liquid primer recommended by manufacturer of sheet waterproofing material for substrate.


3. Asphaltic panels shall be 3/8 inch thick minimum, not less than three (3) feet wide by six (6) feet long, and shall meet the requirements of AREMA Manual, Chapter 29, Part 2, Article 2.4.7.

2.02 BALLAST MAT

A. Ballast mat shall consist of natural rubber with fabric reinforcement designed to provide a reduction in the impact on structures of ground or structure-borne vibrations and in the crushing of ballast. The upper surface of the mat shall be textured to permit ballast to nest for track bed stability and shall contain synthetic elastomers for protection against attack by contaminants that may filter through ballast over time. The subsurface shall contain fabric reinforcement for strength and load distribution. Its underside shall provide a regular pattern of projections in the form of truncated cones.

B. Ballast Mat Material: Materials shall conform to the following requirements:

1. Capacity: Axle load (approximate) 40 Tons

2. Dimensions:
   a. Width: 54 inches minimum, not including joint overlaps
   b. Thickness: 3/4 inch minimum
   c. Length: 30 feet, maximum
3. Fabric (Fiberglass-coated PVC)
   a. Tensile Strength: 60 pounds/inch
   b. Elongation at Break: 10 percent
4. Elastomer Properties (natural rubber)
6. Isolating Layer: 1/2 inch

C. Ballast Mat: Ballast mat shall conform to the following requirements:
   1. Tensile Strength: 2000 psi
   2. Elongation at Break: 100 percent
   3. Tear Resistance: 50 psi
   4. Hardness (Shore A): 50(+/-5)
   5. Dynamics: Dynamic to static stiffness ratio Kd related to a preload of 8.5 psi = 1.86 (+0.1/-free)
   6. Temperature Range: Suitable for service where ballast mat temperatures range between minus 4 degrees F and plus 158 degrees F.

D. Joint Seal: The material used for sealing of the ballast mat joints shall be an integral extension of the top surface of the mat or a separate material having strength characteristics equal to those of the top layer of the ballast mat.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates, areas, and conditions under which waterproofing systems will be applied, with Installer present, for compliance with requirements. Proceed with work after substrate construction, openings, and penetrating work have been completed and areas are free of standing or running water, and frost. Verify deck is dry, smooth, and free from sharp or rough edges, honeycombing, rock pockets, depressions, and projections.

1. Verify substrate is visibly dry and free of moisture. Test for capillary moisture by plastic sheet method according to ASTM D 4263.
2. Correct unsatisfactory conditions prior to proceeding with installation.

B. Existing Decks: Have the necessary materials, equipment, and personnel on stand-by during the cleaning of deck and for making a rapid assessment and repairs to the deck if found to be in a damaged or deteriorated condition.
3.02 SURFACE PREPARATION

A. Clean, prepare, and treat substrate according to manufacturer’s written instructions. Provide clean, dust free, and dry substrate for waterproofing application.

1. Clean in accordance with the waterproofing manufacturer’s recommendation and requirements for the products to be installed.

2. The use of water to clean the deck will not be allowed.

B. Existing Deck Surfaces: Prepare surface to a smooth, sound, monolithic condition, free of voids, spalled areas, sharp protrusions, and loose aggregate as instructed or approved by the waterproofing manufacturer in writing. Remove old membrane, oil grease or other contaminants.

C. Mask off adjoining surfaces not receiving primer and waterproofing to prevent spillage affecting other construction.

D. Remove grease, oil, form release agents, paints, and other penetrating contaminants from surface.

E. Remove fins, ridges, mortar, and other projections and fill honeycomb, aggregate pockets, holes, and other voids.

F. Prepare, fill, prime, and treat joints and cracks in substrate. Remove dust and dirt from joints and cracks according to ASTM D 4258.

1. Install 28 inch wide additional membrane strip and 20 inch wide 16 gauge galvanized sheet metal cover plate centered over construction, control joints, and expansion joints, and cracks less than 1/4 inch in width.

2. In addition to the requirements specified above for joints and cracks less than 1/4 inch in width, all joints greater than 1/4 inch shall have a 1/2 inch by 10 inch wide galvanized steel plate installed prior to the 16 gauge sheet metal plate and the membrane strip.

G. Inside Corners: Prepare, prime, and treat inside corners according to waterproofing manufacturer’s written instructions.

1. Install membrane strip centered over vertical inside corners. Install 3/4 inch fillets of liquid membrane on horizontal inside corners and as follows:

   a. At footing to wall intersections, extend liquid membrane each direction from corner or install membrane strip centered over corner.

   b. At deck to wall intersections, extend sheet membrane flashing onto deck waterproofing and to finished height of sheet flashing.

H. Outside Corners: Prepare and treat outside corners according to waterproofing manufacturer’s written instructions.
1. Install strip of membrane 12 inches wide, centered over corner.

I. Prepare, treat, and seal vertical and horizontal surfaces at terminations and penetrations through waterproofing and at drains and protrusions according to waterproofing manufacturer’s written instructions.

3.03 SHEET APPLICATION

A. Install waterproofing membrane according to waterproofing manufacturer’s written instructions.

1. Apply primer to substrate at required rate and allow to dry. Limit priming to areas covered by waterproofing membrane in same day. Re-prime areas exposed for more than 24 hours.

2. Apply from low point to high point in both the longitudinal and transverse directions.
   a. In the transverse direction, overlap in shingle fashion 2-1/2 inch after removing the white polyethylene strip that exposes the 3/4 inch rubberized asphalt.
   b. In the longitudinal direction, overlap six (6) and seal with manufacturer’s recommended mastic.

3. Once positioned, immediately hand rub waterproofing membrane onto the substrate. Follow by a pressure-applied roll-pressing of the complete surface.

4. Seal all terminations with manufacturer’s recommended pointing mastic.

5. Install sheet membrane and auxiliary materials to tie in adjacent waterproofing.

6. Repair tears, voids, and lapped seams in waterproofing not meeting requirements. Slit and flatten fishmouths and blisters. Patch with sheet membrane extending 6 inches (150 mm) beyond repaired areas in all directions.

3.04 APPLICATION OF MEMBRANE PROTECTION

A. Apply with applicable requirements of the AREMA Manual, Chapter 29, Part 2, for applying membrane protection.

B. Asphaltic panel membrane protection shall be placed within 24 hours after completion of the membrane application. Install asphaltic panels in accordance with the manufacturer’s installation instructions and recommendations, for protection from subsequent construction operations and ballast installation. Asphaltic panels damaged during subsequent construction operations shall be properly repaired or replaced immediately.
3.05 BALLAST MAT

A. Install ballast mat on waterproofing membrane soon after application according to ballast mat manufacturer’s written instructions and before commencing subsequent construction operations.

B. Install ballast mat directly on the waterproofed deck cleaned of all debris and dust. Remove rough or uneven areas by grinding until the surface is acceptable and re-waterproof as required. Obtain Engineer’s inspection and approval of intersections of ballast plate and recesses prior to installing the mats.

C. Place overlay from low point to high point with caution. Overlap the mat sections as required by the instructions.

D. Cut the ends of the ballast mat rolls square and in a neat straight line. Seal the joint with repair tape or other material as specified by the ballast manufacturer.

E. Prevent intrusion of silt and debris into the void space between the cones of the ballast mat. Protect the joints and place the z-fastener strips over the edges of the ballast mat as soon as the mat is installed. At no time allow water, silt, or debris to enter into the newly installed ballast mat from the adjacent track or from other sources. Install temporary positive seals along the open edges of the mat to prevent such intrusion.

3.06 FIELD QUALITY CONTROL

A. Field inspections and sampling and testing materials to verify that work of this Section conforms to the specified requirements shall be performed by the independent Inspection and Testing Agency hired by the Contractor.

B. After surface preparation and before commencing waterproofing installation, waterproofing manufacturer field representative shall provide a written statement of the suitability the deck to receive the waterproofing.

C. Correct deficiencies in or remove waterproofing that does not comply with requirements, repair substrates, reapply waterproofing, and repair sheet flashings.

1. Repair defects and make further repairs until waterproofing installation is watertight.

D. Additional testing shall be performed to determine compliance of corrected work with requirements.

3.07 PROTECTION

A. Protect waterproofing from damage and wear during application and remainder of construction period, according to manufacturer’s written instructions.

B. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.
C. Remove ballast mats contaminated with silt and debris, clean and reinstall or replace with new materials.

END OF SECTION
SECTION 07250
JOINT SEALANTS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Section includes specifications for joint sealants and accessories.

1.02 REFERENCE STANDARDS

A. American Society for Testing and Materials (ASTM International):
   1. C920 Specification for Elastomeric Joint Sealants
   3. D1751 Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)

B. American Concrete Institute (ACI):
   1. 504R Guide to Sealants for Concrete Structures

1.03 SUBMITTALS

A. Shop Drawings: Submit details to show installation and interface between sealants and adjacent work.

B. Product Data: Submit materials list of items proposed to be provided under this Section and manufacturer’s specifications and other data needed to prove compliance with the specified requirements.

C. Samples:
   1. Submit color samples including project specific non-standard colors developed by the manufacturer as required, matching the indicated color for each sealant type for initial selection. In addition, submit the manufacturer’s standard color charts for initial selection.
   2. Submit for final approval cured color samples for each sealant type illustrating selected colors.

D. Manufacturer’s Installation Instructions: Submit manufacturer’s published installation procedures. Include instructions for completing sealant intersections when different materials are joined.
E. Manufacturer’s Certificate:

1. Certify products are suitable for intended use including hardness appropriate for pedestrian traffic areas and products meet or exceed specified requirements.

2. Certify applicator is approved by manufacturer.

3. Submit letter signed by a representative of the manufacturer confirming the compatibility of joint-shaping materials with sealant and release tapes with sealant.

4. Certify joint backing is that recommended by the sealant manufacturer to suit joint sealant application.

1.04 DELIVERABLES

A. Qualifications Data: Submit applicator’s qualifications, including reference projects of similar scope and complexity, with current phone numbers and contact names of architects and owners for verification.

B. Operation and Maintenance Data: Submit data including recommended inspection intervals and instructions for repairing and replacing failed sealant joints.

1.05 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum ten years documented experience.

B. Applicator Qualifications:

1. Company specializing in performing work of this section with minimum three years documented experience, minimum three successfully completed projects of similar scope and complexity, and approved by manufacturer.

2. Designate one individual as project foreman who shall be on site at all times during installation.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Store primers and sealants in accordance with the manufacturers’ printed recommendations and the following: Store in cool dry location with ambient temperature range of 60 to 80 degrees F.

1.07 ENVIRONMENTAL REQUIREMENTS

A. Install primers and sealants in accordance with ACI 504R and the manufacturer’s printed recommendations. Do not install primers or sealants when atmospheric temperatures or joint surfaces temperatures are below 40 degrees F.
**1.08 WARRANTY**

A. Submit signed copies of the warranties against adhesive and cohesive failure of sealant and against infiltration of water and air through sealed joint for period of 3 years from date of completion. Include the following warranties:

1. Manufacturer’s warranty covering sealant materials
2. Applicator’s warranty covering workmanship

**PART 2 – PRODUCTS**

**2.01 GENERAL**

A. Like items of materials shall be supplied by one manufacturer to achieve standardization for appearance, maintenance, and replacement throughout the project, unless otherwise approved by the Engineer.

B. Sealant characteristics shall be as follows:

1. Uniform, homogeneous
2. Free from lumps, skins, and coarse particles when mixed
3. Non-staining, non-bleeding

C. Unless specifically noted, sealant color shall match the adjoining area.

D. Use as few sealant types as possible to meet the requirements of the Work.

E. Joint sealants are specified in other Sections, including the following:

1. Section 02700, Station Platforms, Sidewalks, Curbs and Gutters
2. Section 03150, Concrete Accessories: Includes expansion joints, joint fillers, and sealers
3. Section 09650, Detectable Guide Tactiles: Sealant installed with tiles
4. Section 09655, Detectable Warning Tactiles: Sealant installed with panels

**2.02 SEALANT TYPES**

A. Type A: Multi-Component Urethane: ASTM C920, Type M, Grade NS, Class 25 or Class 50 as required for application; Uses NT, M, A, and O; two component, chemical curing, non-staining, non-bleeding, color as selected.

B. Type B: Multi-Component Self-Leveling Urethane: ASTM C920, Type M, Grade P or NS as appropriate for application, Class 25, Uses T; self leveling, multi-component, chemical curing, non-staining, non-bleeding, color as selected.
2.03 ACCESSORIES

A. Joint Cleaner: Non-corrosive and non-staining type, recommended by sealant manufacturer; compatible with joint forming materials.

B. Primer: Non-staining type, recommended by sealant manufacturer to suit application.

C. Joint Backing: Round foam rod compatible with sealant; oversized 25 to 50 percent larger than joint width; recommended by sealant manufacturer to suit application.

D. Bond Breaker: Pressure sensitive tape recommended by sealant manufacturer to suit application.

E. Masking Tape: Non-staining, non-absorbent tape product compatible with joint sealants and adjacent joint surfaces.

F. Joint Filler: Pre-molded asphalt impregnated felt conforming to ASTM D1751.

PART 3 – EXECUTION

3.01 GENERAL

A. Use of more than a single type of sealant for the same joint will not be permitted.

B. Horizontal and Sloping Joints of up to one (1) Percent Slope: Self-leveling joint sealant or nonsag sealant shall be used.

C. Joints steeper than 1 Percent Slope, Vertical Joints, and Overhead Joints: Nonsag joint sealant shall be used.

D. Prepare joints and install primers and joint sealants in accordance with ASTM C1193, the manufacturers instructions, and ACI 504R.

3.02 PREPARATION

A. Verify joint dimensions and physical and environmental conditions prior to sealant application.

B. Verify that surfaces to be sealed are clean, dry, sound, and free of dust, loose mortar, oil, and other foreign materials. Correct nonconforming conditions.

1. Clean concrete surfaces by abrasive blasting

2. Hand or mechanical clean as required by the product manufacturer and as approved by the Engineer

3. Mask adjacent surfaces where necessary to maintain neat edges

4. Apply primer, where required, to dry surfaces
3.03 INSTALLATION

A. Install sealant systems to achieve the required width/depth ratios shown on the Contract Drawings. If width/depth is not indicated on the Contract Drawings, comply with the manufacturer’s product data.

B. Joint filler shall be used to achieve the required joint depths.
   1. Install backup material in accordance with the sealant manufacturer’s printed recommendations.
   2. Use full-length sections of joint-filler material. Where splices are required, minimize the number of splices. Splices shall be fitted and neat.

C. Use bond breaker as recommended by sealant manufacturer.

D. Seal expansion joints and elsewhere as shown on the Contract Drawings.

E. Tool joints slightly concave after the sealant is installed, unless otherwise recommended by the manufacturer and approved by the Engineer.

F. Finish joints free of air pockets, foreign embedded matter, ridges, and sags.

3.04 CLEANING

A. Clean surfaces adjacent to the sealed joints of masking tape, sealant, and foreign substances.

B. Damaged surfaces resulting from joint sealing or cleaning activities shall be replaced.

3.05 SCHEDULE

A. Exterior Sealant Joint (Type A) Applications:
   1. Control and expansion joints in cast-in-place concrete
   2. Joints between architectural and structural precast concrete units
   3. Control and expansion joints in unit masonry
   4. Joints between different materials listed above
   5. Other exterior joints in vertical surfaces and non-traffic horizontal surfaces for which no other sealant is specified

B. Traffic Sealant Joint (Type B) Applications
   1. Control, expansion and isolation joints in cast-in-place concrete
2. Control, expansion and isolation joints in structural precast concrete units

3. Joints between architectural precast concrete paving units

4. Tactile control and expansion joints

5. Joints between different materials listed above

6. Other interior and exterior traffic bearing joints in horizontal and sloped traffic surfaces

END OF SECTION
SECTION 09650
DETECTABLE WARNING TACTILES

PART 1 - GENERAL

1.01 DESCRIPTION

A. Section includes specifications for detectable warning tactile panels for installation at the following locations: Station platform edge, and the pedestrian crossings at stations, and at vehicular grade crossings. See Section 09655 for detectable guide tactiles.

B. The tactile panels (panels) shall be surface install for installation only on concrete surface.

1.02 REFERENCE STANDARDS

A. ADA (Americans with Disability Act) Standards for Accessible Design, 2010 or latest

B. American Society for Testing and Materials (ASTM International):

1. B117 Practice for Operating Salt Spray (Fog) Apparatus

2. C501 Test Method for Relative Resistance to Wear of Unglazed Ceramic Tile by the Taber Abraser

3. C1028 Test Method for Determining the Static Coefficient of Friction of Ceramic Tile and Other Like Surfaces by the Horizontal Dynamometer Pull-Meter Method

4. D570 Test Method for Water Absorption of Plastics

5. D638 Test Method for Tensile Properties of Plastics


7. D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials


11. G155  Practice for Operating Xenon-Arc Light Apparatus for Exposure of Non Metallic Materials

C. Caltrain Standard Drawings

1.03 SUBMITTALS

A. Shop Drawings: showing fabrication details; panel surface profile; fastener locations; plans of panel placement including joints, and material to be used as well as outlining installation materials and procedure. Include procedures for containment and disposal of milling and sawcutting waste water.

B. Product Data: manufacturer’s literature describing products and installation procedures. Include product data for adhesives and sealants.

C. Samples:

1. Samples of panels measuring at least 12 inches x 12 inches. Panel sampled shall include longitudinal edge with integral flange and transverse ship-lap edges.

2. Samples of panels and sealant for verification of color match.

D. Maintenance Instructions: manufacturer’s specified maintenance practices for each type of panel and accessory as required.

E. Quality Assurance Submittals:

1. Material Test Reports: test reports from qualified independent testing laboratory indicating that materials proposed for use are in compliance with requirements and meet the properties specified in this Section. Tests which indicate performance for the panels shall have been performed within three (3) years of the Invitation to Bid.

2. Submit list of projects in California that successfully demonstrate the proposed products’ durability and weatherability.

1.04 QUALITY ASSURANCE

A. Panels and accessories, including panel adhesive, fasteners, and sealants, shall be from a single source. Products shall have been in successful service for a period of five (5) years.

B. Installer’s Qualifications: Engage an experienced Installer certified in writing by panel manufacturer as qualified for installation, who has successfully completed panel installations similar in material, design, and extent to that indicated for Project. Only persons who are thoroughly trained and experience in the installation of the panels shall perform the work.

C. Provide services of manufacturer’s field representative who shall be present at all times during installation.
1.05 DELIVERY, STORAGE AND HANDLING

A. Panel type shall be identified by part number on packages.

1.06 SITE CONDITIONS

A. Environmental Conditions and Protection: Perform field work only when environmental conditions fall within those recommended by manufacturers of the products.

1.07 WARRANTY

A. Panels shall be covered by a written warranty for a period of five (5) years from date of final completion. The warranty includes defective work, breakage, deformation, delamination, fading and chalking of finishes, and loosening of panels. Warranty shall include furnishing new materials, removal of existing panels, and installation of new panels.

1.08 EXTRA STOCK

A. Furnish four (4) additional panels of each type of installed panels and corresponding fasteners. Deliver extra stock to location (within 30 mile radius of work site) designated by the Engineer. Furnish extra stock materials from same manufactured lot as materials installed and enclose in protective packaging with appropriate identification.

PART 2 - PRODUCTS

2.01 PANELS

A. Manufacturers: Subject to conformance with the requirements of this Section, use products fabricated by the following manufacturers may be acceptable, or other Engineer approved equal:

1. ADA Solutions, Inc.

2. Transit-Tile

3. Armor-Tile by Engineered Plastics, Inc.

B. Panels shall be homogenous glass and carbon reinforced composite or an epoxy polymer composition which is color and UV stable. Color shall be Federal Safety Yellow (FS 33538) and homogenous throughout the panel thickness.

C. Truncated Dome Geometry:

1. Truncated dome surface shall comply with ADA and ABA guidelines, 705, Detectable Warnings. (Title 49 CFR Transportation, Part 37.9 Standards for Accessible Transportation Facilities, Appendix A, Section 4.29.2 – Detectable Warnings on Walking Surfaces).
2. Truncated Dome Description:
   a. Staggered Dome and In-Line Patterns (nominal dimensions):
      The truncated dome shall measure 0.45 inch diameter at the top
      of the dome, 0.90 inch diameter at the base of the dome, 0.20
      inch high, and 1.6 inch on center (staggered pattern) and 2.35
      inch on center (in-line pattern).
   b. In order to ensure a uniform appearance of the detectable
      warning surface throughout the system, equivalent facilitation
      findings or alternate patterns will not be acceptable.

3. Truncated dome pattern shall align properly from Panel to Panel.

D. Panel Configuration:

   1. Panel thickness: 3/8 inches minimum, solid thickness for all type of
      panels.

   2. Butt Joint, Staggered Truncated Domes:
      a. For station platform edge (staggered pattern): Nominal 24 inches ×
         48 inches with a 7/16-inch thick deep flange along both long sides.
         The perimeter of the standard panel features a chamfer (no 90
         degree return).
      b. For station pedestrian crossings (staggered pattern): Nominal 36
         inches × 48 inches (or longer) with a 7/16-inch thick deep flange
         along both long sides. The perimeter of the standard panel features
         a chamfer (no 90 degree return).
      c. For pedestrian crossings at vehicular crossings (in-line pattern):
         Nominal 36 inches × 48 inches (or longer) with a 7/16-inch thick
         deep flange along both long sides. The perimeter of the standard
         panel features a chamfer (no 90 degree return).

   2. The panel shall feature a butt joint detail from tactile warning panel to
      panel. Alternatively a ship lap detail may also be furnished.

E. Fastener Holes in the Panel:

   1. Holes for fasteners shall be formed in the factory. The holes shall be
      located only at the centers of the truncated domes.

F. Performance characteristics: Panels shall meet the following standards.

<table>
<thead>
<tr>
<th>Property</th>
<th>ASTM Test Method</th>
<th>Nominal Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accelerated Weathering (2,000 hours)</td>
<td>G155</td>
<td>Delta E: 5.0 max</td>
</tr>
<tr>
<td>Chemical Resistance</td>
<td>D1308</td>
<td>No Stain or Discoloration</td>
</tr>
<tr>
<td>Flexural Strength</td>
<td>D790</td>
<td>25,000psi min</td>
</tr>
</tbody>
</table>
### Compressive Strength

<table>
<thead>
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<th>Test Method</th>
<th>Test Reference</th>
<th>Minimum Value</th>
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</thead>
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<td>D695</td>
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### Tensile Strength

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<tr>
<th>Test Method</th>
<th>Test Reference</th>
<th>Minimum Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>D638</td>
<td>10,000psi min</td>
<td></td>
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</tbody>
</table>

### Gardner Impact Test

<table>
<thead>
<tr>
<th>Test Method</th>
<th>Test Reference</th>
<th>Minimum Value</th>
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</thead>
<tbody>
<tr>
<td>D5420</td>
<td>110 in-lb min</td>
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</table>

### Flame Spread

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<tr>
<th>Test Method</th>
<th>Test Reference</th>
<th>Maximum Value</th>
</tr>
</thead>
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<tr>
<td>E84</td>
<td>FSI: 25 max</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SDI: 150 max</td>
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</table>

### Slip Resistance

<table>
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<tr>
<th>Test Method</th>
<th>Test Reference</th>
<th>Minimum Friction Coefficient</th>
</tr>
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<tbody>
<tr>
<td>C1028</td>
<td></td>
<td>0.80 (wet or dry)</td>
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</table>

### Wear Resistance

<table>
<thead>
<tr>
<th>Test Method</th>
<th>Test Reference</th>
<th>Minimum Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>C501</td>
<td>500 min</td>
<td></td>
</tr>
</tbody>
</table>

### Water Absorption (2 weeks)

<table>
<thead>
<tr>
<th>Test Method</th>
<th>Test Reference</th>
<th>Maximum Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>D570</td>
<td>0.20% max</td>
<td></td>
</tr>
</tbody>
</table>

### Salt Spray (120 hours)

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<thead>
<tr>
<th>Test Method</th>
<th>Test Reference</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B117</td>
<td>No Change</td>
</tr>
</tbody>
</table>

## 2.02. ACCESSORIES

A. Fasteners for Concrete: Color matched nylon expansion sleeves with 1/4 inch diameter by 1-1/2 inches long stainless steel drive pins or as recommended by panel manufacturer for specific job conditions and accepted by the Engineer.

B. Adhesive: Type approved by the panel manufacturer.

C. Sealant: Urethane sealant of type approved by the panel manufacturer.

D. Backer Road: Acceptable to sealant manufacturer. Where required, such as at platform expansion joints.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

A. Apply adhesives, sealants and mechanical fasteners in accordance with the guidelines provided by their respective manufacturers.

B. Utilize manufacturer-provided template to lay out area to receive panels.

C. Form recess for panels by either milling with diamond blade head or casting recess in place (at new paving) so that installed panel will still flush relative to adjacent surface. Grind or form to the depth and width required by the approved shop drawings and manufacturer’s instructions. Finish cast-in-place recess with equivalent of a light broom finish. When milled, substrate shall have a light ribbed finish.

D. Contain and remove slurry resulting from concrete milling and sawcutting. Do not wash slurry into track bed area. Slurry contaminates and stains track structure and impedes drainage.

E. For Panels with Recessed Flanges:

1. Utilize diamond bladed double headed wet saw to achieve parallel grooves to receive panels. Both sawcuts shall be made simultaneously from the same machine. Sawcut parallel to platform edge.

2. After sawcutting, vacuum and power wash surface with clean clear water, free from all dirt and debris. Visually inspect surface for
obtrusions or foreign matter. If obtrusions are present, remove by
grinding. Remove foreign matter by grinding or further washing, as
appropriate.

F. Immediately prior to application of the setting adhesive, inspect surfaces to
receive panel to ensure that they are clean, dry, free of voids, curing
compounds, projections, loose material, dust, oils, grease, sealers, and other
contaminants. Verify that surfaces are structurally sound and that concrete has
cured a minimum of 30 days. Obtain panel manufacturer’s representative’s and
Engineer’s approval of surface preparation before installing panels.

G. Air entrapment: Apply generous amount of adhesives to eliminate air
entrapment between the panels and the concrete surfaces.

H. Set panels and install fasteners in accordance with panel manufacturer’s
instructions and as follows:

1. Wherever possible, install full size (uncut) panels. Do not install panel
sections measuring less than 24 inches in length. Only cut panels where
absolutely necessary.

2. Maintain gap between panels for expansion and contraction in
accordance with manufacturer’s instructions.

3. At platform expansion joints, cut panels on their short sides, finish cut
edges smoothly, and lay panels with cut edges aligned with the edges of
the substrate along the joints. Install fasteners on either side of the
expansion joint at the time of initial installation. After a minimum of 4
hours, make a sawcut measuring 5/16 inch wide across the composite
detectable warning surface panel and fill with sealant. Make sawcut in
the zone between truncated domes.

a. Where there is platform curvature, composite detectable
warning surface panels shall be treated in a similar manner so
that the joints remain uniform across the width of the joint
between successive panels. However, in areas of platform
curvature, the joint shall take on somewhat of a triangular
configuration.

4. Cutting through panel domes shall be kept to a minimum. Where less
than half of the truncated dome remains, grind off balance of dome;
where over half of the truncated dome remains, feather dome so as not
to present a tripping hazard.

I. Install sealant in accordance with manufacturer recommendations.

3.02 CLEANING AND PROTECTING

A. After the area has been fully tiled and sealant system applied, clean panel
surface, following the manufacturer recommended maintenance and cleaning
procedures.
B. Protect sealant and panels against damage during construction period. Comply with panel and sealant manufacturers’ recommendations.

C. Protect panels against damage from rolling loads following installation by covering with plywood or hardwood.

D. Clean panel by method specified by the manufacturer.

END OF SECTION
SECTION 09655
DETECTABLE GUIDE TACTILES

PART 1 - GENERAL

1.01 DESCRIPTION

A. Section includes specifications for surface applied and recessed detectable guide or directional tactiles (tactiles) for use on the station platforms to provide guidance or direction to the Ticket Vending Machines (TVMs) and the passenger shelters, as well as to mark the location of the mini-high platforms.

B. The tactiles shall be surface install for installation only on concrete surface.

1.02 REFERENCE STANDARDS

A. American Society for Testing and Materials (ASTM International):
   1. B117 Practice for Operating Salt Spray (Fog) Apparatus
   2. C501 Test Method for Relative Resistance to Wear of Unglazed Ceramic Tile by the Taber Abraser
   3. C1028 Test Method for Determining the Static Coefficient of Friction of Ceramic Tile and Other Like Surfaces by the Horizontal Dynamometer Pull-Meter Method
   5. D570 Test Method for Water Absorption of Plastics
   7. D695 Test Method for Compressive Properties of Rigid Plastics
   10. D5420 Test Method for Impact Resistance of Flat, Rigid Plastic Specimen by Means of a Striker Impacted by a Falling Weight (Gardner Impact)
   12. G155 Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials
1.03 SUBMITTALS

A. Shop Drawings: Submit shop drawings showing fabrication details; tactile surface profile; fastener locations; plans of tactile placement including joints, and material to be used as well as outlining installation materials and procedure.

B. Product Data: Submit manufacturer’s literature describing products and installation procedures. Include product data for sealants.

C. Samples: Submit samples of tactile and sealant for verification of color match.

D. Samples for Verification Purposes: Submit samples of full size tactiles of the kinds proposed for use.

E. Maintenance Instructions: Submit copies of manufacturer’s specified maintenance practices for each type of tactile tile and accessory as required.

F. Quality Assurance Submittals:
   1. Material Test Reports: Submit test reports from qualified independent testing laboratory indicating that materials proposed for use are in compliance with requirements and meet the properties in this Section.
   2. Submit list of projects in California that successfully demonstrate the proposed products durability and weatherability.

1.04 QUALITY ASSURANCE

A. Provide tactiles and accessories as produced by a single manufacturer. Products shall have been in successful service for a period of two (2) years.

B. Installer’s Qualifications: Engage an experienced installer certified in writing by tile manufacturer as qualified for installation, who has successfully completed tactile installations similar in material, design, and extent to that indicated for Project.

1.05 DELIVERY, STORAGE AND HANDLING

A. Tactile type shall be identified by part number on packages.

1.06 SITE CONDITIONS

A. Environmental Conditions and Protection: Perform field work only when environmental conditions fall within those recommended by manufacturers of each product.

1.07 WARRANTY

A. Tactiles shall be covered by a written warranty for a period of five (5) years from date of final completion. The warranty includes defective work, breakage, deformation, fading, and chalking of finishes, and loosening of tactiles.
Warranty shall include furnishing of new tactiles, removal of existing tactiles, and installation of new tactiles.

1.08 EXTRA STOCK

A. Furnish 10 linear feet long additional tactiles and corresponding amount of fasteners. Deliver extra stock to location (within 30 mile radius of work site) designated by the Engineer. Furnish extra stock materials from same manufactured lot as materials installed and enclose in protective packaging with appropriate identification.

PART 2 - PRODUCTS

2.01 TILES

A. Nominal dimensions: 6 inches by 48 inches long by 0.125 inches thick and 0.325 inches thick at the top of the bars. Tactiles shall be formed with holes for anchors. Color: Federal Safety Yellow (FS 33538).

B. Manufacturer: Armor Tile directional bar tiles, as manufactured by Engineered Plastics, Inc, or Engineer approved equal.

C. Material: epoxy polymer composition employing aluminum oxide particles in the linear bars. Color shall be homogenous throughout the tactile.

D. Performance characteristics: Tactiles shall meet the following standards.

<table>
<thead>
<tr>
<th>Property</th>
<th>ASTM Test Method</th>
<th>Nominal Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accelerated Weathering (3000 hours)</td>
<td>G155</td>
<td>Delta E: 4.5 max</td>
</tr>
<tr>
<td>Chemical Stain Resistance</td>
<td>D543</td>
<td>No stain or discoloration</td>
</tr>
<tr>
<td>Chemical Resistance</td>
<td>D1308</td>
<td>No Stain or Discoloration</td>
</tr>
<tr>
<td>Flexural Strength</td>
<td>D790</td>
<td>25,000 psi min</td>
</tr>
<tr>
<td>Compressive Strength</td>
<td>D695</td>
<td>28,000 psi min</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>D638</td>
<td>19,000 psi min</td>
</tr>
<tr>
<td>Gardner Impact Test</td>
<td>D5420</td>
<td>550 in-lb min</td>
</tr>
<tr>
<td>Flame Spread</td>
<td>E84</td>
<td>FSI: 15 max</td>
</tr>
<tr>
<td>Slip Resistance</td>
<td>C1028</td>
<td>Friction Coeff: 0.80 min</td>
</tr>
<tr>
<td>Wear Resistance</td>
<td>C501</td>
<td>500 min</td>
</tr>
<tr>
<td>Water Absorption (2 weeks)</td>
<td>D570</td>
<td>0.05% max</td>
</tr>
<tr>
<td>Salt Spray (200 hours)</td>
<td>B117</td>
<td>No Change</td>
</tr>
</tbody>
</table>

2.02. ACCESSORIES

A. Fasteners: Stainless steel low profile expansion anchors 3/16 inch diameter by 2 inches long.

B. Adhesive: Type approved by the tactile manufacturer.
C. Sealant: Urethane sealant of type approved by the tactile manufacturer.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Apply adhesives, sealants and mechanical fasteners in strict accordance with the guidelines set by their respective manufacturers.

B. Lay out area to receive tactile and mark with a thin indelible felt pen a reference grid for the tile to be laid. Lines shall be covered by tile or sealant or removed in completed installation.

C. Set the diamond head planer to the appropriate depth to achieve the necessary recess in the area to receive the tactile.

D. After planing, vacuum and power wash surface with clean clear water, free from all dirt and debris. Visually inspect surface for obtrusions or foreign matter. If obtrusions are present, remove by grinding. Remove foreign matter by grinding or further washing, as appropriate.

E. Immediately prior to application of the setting adhesive, inspect surfaces to receive tactile to ensure that they are clean, dry, free of voids, curing compounds, projections, loose material, dust, oils, grease, sealers, and other contaminants. Verify that surfaces are structurally sound and that concrete has cured a minimum of 30 days.

F. Clean backs of tactiles in accordance with manufacturer’s instructions.

G. Apply the adhesive to provide a sound resonating affect after the tactile is installed. All perimeter edges of the tactile shall receive a minimum of a 1 inch perimeter bond of adhesive.

H. Inspect the tactile and clean with acetone all dust and other contaminants from the surfaces to be adhered, then set the tile in place, true and square. Drill holes true and straight to the depth required using the recommended bit with holes located by the molded recesses provided in the tactile. Clean dust from the holes with acetone to provide clear passage for the anchor and eventually the concealed cap.

I. Mechanically fasten tactiles to surface using equipment and technique per manufacturer’s instructions. Ensure the fastener has been set to full depth, straight and true, leaving sufficient clearance between the top of fastener and top of dome to not interfere with the concealed cap. Prevent damage to tile surface from inadvertent blows with the hammer.

J. Maintain gap between tactiles for expansion and contraction in accordance with manufacturer’s instructions.

K. Following the installation of the tactiles, apply sealant to the joint between abutting tactiles and between tactiles and adjacent surface in accordance with
sealant manufacturer instructions, including masking and tooling. Clean joint and remove any debris. Cut away any excess adhesive. At sawcut, cut away any excess adhesive to provide sufficient depth for the sealant in the saw cut as indicated on the Contract Drawings.

3.02 CLEANING AND PROTECTING

A. After the area has been fully tiled and sealant system applied, clean tactile surface, following the manufacturer recommended maintenance and cleaning procedures.

B. Protect panels against damage during construction period to comply with tile manufacturer’s specification.

C. Protect tactiles against damage from rolling loads following installation by covering with plywood or hardwood.

D. Clean tactiles not more than 4 days prior to date schedule for inspection intended to establish completion for each area. Clean tactile by method specified by the manufacturer.

END OF SECTION
SECTION 09900
PAINTS AND COATINGS

PART 1 - GENERAL

1.01 DESCRIPTION
A. Section includes specifications for paints and coatings.

1.02 DEFINITIONS
A. Paint: As used herein, means coating systems materials including primers, emulsions, epoxies, enamels, sealers, fillers, and other applied materials whether used as primer, intermediate, or finish coats.

1.03 EXCLUDED WORK
A. Do not paint metal surfaces of anodized aluminum, stainless steel, and similar finished materials, unless otherwise noted on the Contract Documents.
B. Do not paint over required labels or equipment identification, performance rating, name, or nomenclature plates.
C. Do not paint glass, concrete with sealer, nor other finished surfaces, unless otherwise noted or on the Contract Documents.

1.04 SUBMITTALS
A. Product Data: a complete list of materials proposed for use, together with manufacturer product specifications.
B. Samples:
   1. Five 8.5 inches by 11 inches samples of each color and each gloss for each material on which the finish is specified to be applied for review and approval of the Engineer.
   2. Revise and resubmit each sample until the required gloss, color, and texture is achieved. Samples approved by the Engineer will become standards of color and finish for accepting or rejecting the work of this Section.
   3. Final approval of gloss, color, and texture shall be made through approval of mockups, if required by the Engineer.
C. Certificates of Compliance: Certificates of compliance from manufacturer certifying that proposed materials comply with the specified requirements and are the manufacturer's best-quality grade materials.
D. Manufacturers' Review: Record of paint manufacturer's review as specified herein.
1.05 QUALITY ASSURANCE

A. Regulations: In case of conflict between regulatory requirements and specified materials, submit alternative materials to the Engineer for approval.

B. Manufacturer’s Standards: Comply with manufacturer’s recommendations and standards

C. Personnel: Use adequate number of skilled workers who are thoroughly trained and experienced in the necessary crafts; and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section.

D. Paint Coordination:
   1. Provide finish coats that are compatible with the prime coats actually used.
   2. Review the Contract Documents, verify the prime coats to be used, and ensure compatibility of the total coating system for the various substrata.

E. Paint Manufacturer’s Review: Before purchasing paint materials, review the proposed paint systems, materials, and substrates with qualified representatives of the proposed paint product manufacturers. Obtain manufacturer’s concurrence of the proposed paint systems, or any recommended changes thereto, before providing product data, samples, and mock-ups specified herein.

F. Mockups:
   1. Do not apply final coats until the colors and textures have been approved by the Engineer. To accomplish this, if requested by the Engineer, paint a sample panel of approximately 24 square feet of the colors and textures selected on every type of surface to be painted. Notify the Engineer at least three days in advance of when sample panels will be ready for review and approval.
   2. For interior finishes, permanent lighting shall be installed and in operation in the rooms or areas where the sample panels have been painted. Temporary lights at the same level and of the same type, intensity, and color as the permanent lights will be permitted for viewing of sample panels.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to job in original packages and containers bearing name of manufacturer; containers shall be new and unopened and shall clearly show manufacturer’s best-grade certification on each container; store appropriately and provide fire protection.

B. When materials are not in use, store in hermetically covered containers.
1.07 SITE CONDITIONS

A. Environmental conditions specified herein are minimum parameters. Comply with manufacturer's requirements.

B. Do not apply solvent-thinned paints when the temperature of surfaces to be painted and the surrounding air temperatures are below 45 degrees F unless otherwise permitted by the manufacturer's published instructions.

C. Weather Conditions:
   1. Do not apply paint when the relative humidity exceeds 85 percent; or to damp or wet surfaces, unless otherwise permitted by the manufacturer's published instructions.
   2. Do not apply paint when dust is blowing.

PART 2 - PRODUCTS

2.01 PAINT MATERIALS AND COLORS

A. Quality: Best quality grade of specified types as regularly manufactured by recognized paint and varnish manufacturers; materials not bearing manufacturer's identification as standard best grade product of regular line are not acceptable.

B. Undercoats and Thinners:
   1. Provide undercoat paint produced by the same manufacturer as the finish coat.
   2. Use only the thinners recommended by the paint manufacturer and use only to the recommended limits.
   3. Undercoat, finish coat, thinner material, and related elements shall be components of a unified paint finish system.

2.02 MATERIAL LIST

A. Metal Treatment and Primers:
   1. Rust Inhibitive Primer: Compatible formulation with shop applied primer and subsequent coats.

B. Exterior Prime Coats
a. ICI Dulux Paints; 4020-XXXX Devflex DTM Flat Interior/Exterior Waterborne Primer & Finish: Applied at a dry film thickness 2.2 mils minimum.

b. Kelly-Moore; 1725 Kel-Guard Acrylic Metal Primer: Applied at a dry film thickness of 1.5 to 2.0 mils.

c. Kelly-Moore; 5725 DTM-Acrylic Metal Primer: Applied at a dry film thickness 1.5 to 2.0 mils, under full-gloss acrylic-enamel coatings.

d. Sherwin-Williams; Pro-Cryl Universal Metal Primer B66: Applied at a dry film thickness 3.0 mils minimum.

e. Or equal.

2. Exterior Galvanized Metal Primer: Factory-formulated galvanized metal primer for exterior application.

a. ICI Dulux Paints; 4020-XXXX Devflex DTM Flat Interior/Exterior Waterborne Primer & Finish: Applied at a dry film thickness 2.2 mils minimum.

b. Kelly-Moore; 1725 Kel-Guard Acrylic Metal Primer: Applied at a dry film thickness of 1.5 to 2.0 mils.

c. Sherwin-Williams; Pro-Cryl Universal Metal Primer B66: Applied at a dry film thickness 2.0 mils minimum, under full-gloss acrylic-enamel finishes.

d. Or Engineer approved equal.

C. Exterior Finish Coats


2. ICI Dulux Paints; 4216 Lifemaster Pro High Performance Waterborne Acrylic Semi-Gloss Finish: Applied at a dry film thickness 1.3 mils minimum.


5. Or Engineer approved equal.
D. Heavy Duty Exterior Prime Coats: Exterior Metal Primer for Urethane: Factory-formulated metal primer for exterior application. For shop primed or galvanized ferrous metal:

1. Ameron Amercoat 240, 4-12 mils dry film thickness, each coat.

2. ICI Dulux Paints: 203, Devan Universal Epoxy Primer, 2 to 4 mils dry film thickness, each coat.


4. Or Engineer approved equal.

E. Heavy Duty Exterior Finish Coats: Exterior Gloss Urethane, factory-formulated gloss urethane for exterior application. The dry film thickness shall meet that recommended in manufacturer’s product data.

1. Ameron Amercoat 450HSG, 2-3 mils dry film thickness, each coat

2. ICI Dulux Paints: Devthane 378 UVA Aliphatic Urethane Gloss Enamel, 2-3 mils dry film thickness, each coat.


4. Or Engineer approved equal.

F. Miscellaneous:


G. Provide other materials not specified but required for a complete and proper application, as selected by the Contractor for approval by the Engineer.

2.03 APPLICATION EQUIPMENT

A. Spray and Roller Equipment: Proper type for work, subject to the approval of the Engineer.

PART 3 – EXECUTION

3.01 SURFACE CONDITIONS

A. Examine the areas and conditions under which work of this Section will be performed. Correct conditions detrimental to timely and proper completion of the Work. Do not proceed until unsatisfactory conditions are corrected.
3.02 MATERIALS PREPARATION

A. General:
   1. Mix and prepare paint materials in accordance with the manufacturer's published instructions.

B. Stirring:
   1. Stir materials before application producing a mixture of uniform density.
   2. Do not stir film, which may form on the surface into the material. Remove the film and strain or filter the material appropriately before using.

3.03 SURFACE PREPARATION

A. General:
   1. Cure concrete for a minimum of three (3) weeks prior to applying paint.
   2. Moisten concrete surface prior to applying paint to prevent concrete from absorbing water out of paint.
   3. Concrete: Remove efflorescence, chalk, form release agent, and other materials from surface of concrete which will inhibit adherence and coverage of paint. Brush concrete or apply primer coat of low viscosity penetrant paint to prepare walls and ceiling to receive top coats.
   4. Protect all adjacent finish surfaces from paint including colored concrete pavement, rolling grille, signage, light fixtures, switches and switch boxes, and other finished surfaces.
   5. Perform preparation and cleaning procedures in accordance with the paint manufacturer's published instructions and as approved by the Engineer. Clean concrete and metal surfaces free of all mill rust, form release agents, and efflorescence and prime metals.
   6. Remove removable items, which are in place and are not scheduled to receive paint finish; or provide surface-applied protection prior to surface preparation and painting operations.
   7. Following completion of painting in each space or area, reinstall the removed items by using workers who are skilled in the appropriate trades.
   8. Clean each surface to be painted prior to applying paint of surface treatment.
   9. Remove oil and grease with clean cloths and cleaning solvent of low toxicity and flash point in excess of 200 degrees F prior to start of mechanical cleaning.
10. Schedule the cleaning and painting so that dust and other contaminants from the cleaning process will not fall onto or affect wet newly painted surfaces.

B. Preparation of Metal Surfaces:

1. Thoroughly clean surfaces until free from dirt, oil, grease and the like.
2. On galvanized surfaces, use solvent for the initial cleaning and then treat the surface thoroughly with phosphoric acid etch. Remove etching solution completely before proceeding.
3. Allow to appropriately dry before application of paint.

3.04 PAINT APPLICATION

A. General:

1. The dry film thickness be at least than that recommended in manufacturer's product data. The specified number of coats is the minimum acceptable. If full coverage or required dry film thickness is not attained with specified number of coats, apply additional coats as necessary to achieve coverage and required thickness.
2. Apply material evenly without runs, sags, crawls, holidays, or other defects. For brush work, brush out smooth and leave a minimum of brush marks. Where paint is rolled on, use fine nap roller so that a nearly flat or orange peel texture is obtained.
3. Touch-up shop-applied prime coats, which have been damaged and touch-up bare areas prior to start of finish coats application.
4. Do not apply additional coats until the completed coat has been inspected and approved by the Engineer.
5. Only the inspected and approved coats of paint will be considered in determining the number of coats applied.
6. Sand and clean dust and other debris between coats to remove defects visible to the unaided eye from a distance of 5 feet.
7. On removable panels and hinged panels, paint the back sides to match the exposed sides.

B. Drying and Re-Coat Window:

1. Allow sufficient drying time between coats, modifying the period as recommended by the material manufacturer to suit weather conditions.
2. Comply with manufacturer’s re-coat timing restrictions.
C. Spray Application:
   1. Confine spray application to metal framework and similar surfaces where hand brushwork would be inferior.
   2. Where spray application is used, apply each coat to provide the hiding equivalent of brush coats.
   3. Do not double back with spray equipment to build up film thickness of two coats in one pass.

D. Completed work shall match the samples approved by the Engineer as to texture, color, and coverage.

3.05 FIELD QUALITY CONTROL

A. Testing: Measure thickness of paint on metal with magnetic dry mil thickness gauge to verify that manufacturer designated thickness has been attained and supply the Engineer with a certificate of compliance that said thickness has been attained.

3.06 PROTECTION AND CLEANUP

A. Protection: Protect building elements and components, paving, landscaping, and vehicles from damage, staining, overspray, marking, soiling, and the like. Leave work clean, whole, and as new. Correct damage by cleaning, repairing, replacing, or repainting.

B. Hardware, Fixture Canopies, Outlet Covers, Switch Plates and Similar Items: Remove or loosen and replace as required for painting work. New hardware except for hinges shall not be installed until painting and finishing work is completed; mask and protect hinges from paint or damage.

C. Cleanup: During progress of work clean up discarded paint materials debris cans, rags and the like; remove from the project site. Implement applicable safety methods in control or disposal of flammable materials.

3.07 PAINTING SCHEDULE

A. Exterior Finish System:
   1. Ferrous and other metals: Field apply primer. For shop primed ferrous metal: Touch-up primer as specified in Division 5, Metals.
   2. Intermediate and Finish Coats: As specified in Part 2 of this Section.

B. Heavy Duty Exterior Finish System:
   1. Field apply primer. For shop primed ferrous metal: Touch-up primer as specified in Division 5, Metals.
2. Intermediate and Finish Coats: As specified in Part 2 of this Section.

END OF SECTION
SECTION 09950
GRAFFITI-RESISTANT COATING

PART 1 - GENERAL

1.01 DESCRIPTION
A. Section includes liquid-applied sacrificial surface sealer for concrete that will prevent penetration of staining mediums and allow easy removal and reapplication.

1.02 COATING REQUIREMENTS
A. The coating shall not darken, stain, or discolor substrate surfaces.
B. The coating shall be non-yellowing.

1.03 SUBMITTALS
A. Product Data: Manufacturer’s literature describing product specifications, installation procedures, and general recommendations for specified coating materials.

1. Include instructions and recommendations for cleaning and preparation of concrete surfaces, coating and recoating application techniques, equipment to be used, coverage rates, accessory materials, and special removal procedures.

2. List material and cross-reference the specified coating, finish system, and application. Identify material by manufacturer’s catalog number and general classification.

3. Certification by manufacturer that products supplied comply with local air quality control regulations for volatile organic compounds (VOCs).

B. Samples: Submit 8-inch x 10-inch samples of substrate to receive graffiti-resistant coating, with coating applied to half of each sample.

C. Quality Control: Letter documenting work has been applied in compliance with specifications and manufacturer’s written instructions and that specified field testing has been satisfactory.

1.04 QUALITY ASSURANCE
A. VOC Regulations: Graffiti-resistant coatings shall comply with the latest regulations of the Bay Area Air Quality Management District (BAAQMD) regulations governing permissible content of volatile organic Compounds (VOC).

B. Manufacturer’s Qualifications: Graffiti-resistant coatings shall be furnished by a manufacturer specializing in the manufacture of graffiti-resistant coatings.
C. Applicator’s Qualifications: Application shall be by an applicator certified by the manufacturer who has a minimum of 3 years successful experience in application of similar graffiti-resistant coatings.

D. Coating Manufacturer’s Approval and Job Service:

1. The coatings manufacturer shall inspect and approve coating applications and shall provide field services as part of the Work.

2. Make all necessary arrangements with the coatings manufacturer to provide on-site consultation and inspection services to ensure the proper application and completion of the graffiti-resistant coating system.

3. The coating manufacturer’s representative shall be present at the time any phase of the work is started. Coatings shall be applied only over surfaces previously approved by the coating manufacturer’s representative.

1.05 MOCK-UP

A. Where directed by the Engineer, an area 3 feet x 4 feet of each different concrete substrate shall be treated with full coat finish and evaluated for product adhesion, compatibility, and for acceptability of the appearance of the treated surfaces.

B. Application shall not continue unless each mock-up is acceptable to the Engineer.

1.06 DELIVERY, STORAGE AND HANDLING

A. Deliver and store materials in the manufacturer’s unopened containers labeled with the manufacturer’s name and address and the date of manufacture.

B. Store materials as recommended by manufacturer at site in a protected location, and away from flame and at temperatures between 45 and 90 degrees F.

1.07 SITE CONDITIONS

A. Apply coatings only when temperature of surfaces to receive coatings and surrounding air temperatures between 45 and 90 degrees F, unless otherwise permitted by the coating manufacturer’s printed instructions.

B. Do not apply coatings during periods of fog, mist, and rain, or when rain is imminent.

1.08 EXTRA STOCK FOR MAINTENANCE

A. At completion of the Work, deliver to the Engineer 10 gallons of specified graffiti application solution, and 10 gallons of the cleaning and removal solution.

B. Stock shall be in factory sealed and clearly labeled containers.

C. Stock shall be delivered and stored as directed by the Engineer.
1.09 WARRANTY
   A. Provide one year warranty, or manufacturer’s warranty, whichever is longer.

PART 2 - PRODUCTS

2.01 MANUFACTURERS
   A. Prosoco or Engineer approved equal.

2.02 MATERIALS
   A. Graffiti-resistant coatings, base or prime coat and finish coats, shall be a two-component, polymer-based, non sacrificial product. The finished coating shall be stable, colorless, transparent, low sheen (flat), water soluble product.
      1. Prosoco Sure Klean Weather Seal “Blok-Guard & Graffiti Control II”, or Engineer approved equal.
   B. Coatings shall be weather and rain resistant, abrasive resistant, peel resistant, ultra-violet resistant, non-yellowing, and shall permit moisture vapor relief.
   C. Graffiti-resistant coatings shall have the capability of having all types of paints and graffiti materials completely removed without damaging the uncoated surfaces to which they are applied.
   D. Products required to remove graffiti from the coating shall be non-toxic and shall comply with the local VOC regulations. Removal of graffiti shall cause no damage or change in the appearance of the treated surface.

2.03 ACCESSORIES
   A. Application Equipment: Medium-to-large capacity airless sprayer and hoses or other equipment as recommended by the manufacturer.

PART 3 - EXECUTION

3.01 EXAMINATION
   A. Coating manufacturer’s representative shall verify that surfaces are dry, clean, and free of dust, dirt, grime, oils, alkali or acid residues, and other contaminants or compounds unacceptable to the graffiti-resistant coating manufacturer.
   B. Only apply coating system over surfaces approved by coating manufacturer’s representative.

3.02 PREPARATION
   A. Clean and prepare substrates in accordance with graffiti-resistant coating manufacturer’s instructions.
B. Test for alkalinity and moisture content in accordance with manufacturer’s instructions to ensure that surface is sufficiently dry. If surfaces are sufficiently alkaline to cause the finish coats to blister and burn, correct this condition as recommended by manufacturer before application.

C. Protect adjacent surfaces not to receive coating from spillage or blow-over.

D. Avoid wind drift to adjacent surfaces.

E. Cover adjoining and nearby surfaces of metal and glass as required.

F. Prepare and mix materials in accordance with the coating manufacturer’s instructions and recommendations. Do not dilute or alter.

3.03 APPLICATION

A. Apply graffiti-resistant coating in accordance with manufacturer’s application instructions and recommendations.

B. Apply in thickness and sequence of coats as recommended by coating manufacturer for number of required coats.

C. Completed Work: Match approved samples for texture and coverage. Reccoat work not complying with specified requirements.

3.04 FIELD TEST

A. In the presence of the Engineer, apply and remove graffiti-resistant coatings to the satisfaction of the Engineer.

B. The coating manufacturer’s representative shall be present and provide written acceptance of the graffiti removal test.

3.05 CLEANING

A. Avoid runs or applying coating too heavily as this will impair transparency of cured material. Excessive coating will turn milky when it gets wet after curing.

B. Runs or sags on concrete surfaces shall be immediately brushed out using a clean soft brush.

C. Clean spillage from horizontal surfaces immediately after spillage.

D. Remove temporary protective wrappings after coating operations.

E. Provide ‘WET PAINT’ signs to protect newly coated finishes.

END OF SECTION
SECTION 10100
STATION FURNISHINGS

PART 1 - GENERAL

1.01 DESCRIPTION
A. Section includes specifications for station site furnishings.

1.02 SUBMITTALS
A. Submit manufacturer’s product data and installation instructions.
B. Color Samples:
   1. Powder Coating: Submit manufacturer’s color palette to the Engineer for selection.
   2. Submit manufacturer’s color palette for trash receptacle lids.

PART 2 – PRODUCTS

2.01 SITE FURNISHINGS
A. Benches: Exterior application, Model No. PP423W, Prestige Contour Series, Gullwing – welded wire pattern, as manufactured by Wabash Valley Manufacturing, or Engineer approved equal.
   1. 8 feet length with side and center arms.
   2. Finish: Heavy-duty galvanized steel frame with scratch-resistant finish and “plastisol” coating.
   3. Color: a) Federal ADA blue (for ADA applications), and b) Federal Brown (PMS color 4625) for others.

B. Bike Lockers: Model No. DL100-2-F-P, piano hinged Stainless Steel Dura-Locker, or Engineer approved equal. See Caltrain Standard Drawing.
   1. With floors
   2. Finish: Galvanized
   3. Color: silver gray
   4. Hinges and Fasteners: Door hinge shall be 16 gage piano-type running full height of door frame. Fasteners shall be fastened from the inside only.
   5. Lock Style: Stainless steel heavy duty 4266 Pop-out Chicago ‘T’ handle with two user keys (keyed differently).
C. Bike Racks: Inverted U, SS 316, No. 4 finish for exterior applications, buy Dura Locker, or Engineer approved equal. In ground installation. See Caltrain Standard Drawing.

D. Bird Barrier System: Stealthnet, of Bird Barrier America, Inc., Carson, CA, or Engineer approved equal. Translucent, 3/4 inch mesh. Include attachments, perimeter cables, tensioners, clamps, netting and net rings and access hatches for light fixtures as required for complete installation.

E. Bollards: Galvanized standard weight steel pipe of the size shown on the Contract Drawings for use as traffic bollards.
   1. Steel Pipe: ASTM A 53, Type E or S, Grade B
   2. Nominal diameters: 4 inches (standard applications), and 6 inches (heavy duty applications)
   3. Anchors: Epoxy anchors of the size shown on the Contract Drawings

F. Clipper (aka Translink):
   1. Unit is furnished and installed by others.

G. Convex Mirror: Model No. RP-1426MR, Klear-VU, 24”x 36” roundtangular mirror, acrylic convex with steel back and swivel mount with mounting brackets, as manufactured by Reflection Products, Inc., McHenry, IL, and Roswell, GA, or equal

H. Trash Receptacle: Model QS-CAL2534W-J25, as manufactured by Quick Crete Products Corporation, Norco, CA, or Engineer approved equal.
   1. Precast, reinforced concrete units, top loading
   2. Finish: Sandblast, sand texture (T2) with Tuff Coat, high gloss sealer
   3. Concrete Color: C3 Latte
   4. Lid: Fiberglass - Federal Brown (PMS color 4625), or similar color selected by the Engineer from manufacturer’s standard colors
   5. Poly Liner: Capacity to match receptacle

I. Furnish vandal resistant anchor bolts to suit anchorage in substrate indicated on the Contract Drawings.

J. Furnish anchors, bolts, sleeves, and templates required for complete installation to ensure proper fit and accurate placement.

2.02 FABRICATION

A. Fabricate and finish site furnishings in shop.
B. Provide miscellaneous metal items required for completion of the work.

C. Provide concealed connections where possible. Exposed connections shall be vandal-proof connectors.

PART 3 – EXECUTION

3.01 GENERAL

A. Prior to commencement of work, carefully inspect the installed work of other trades. Verify that all such work is correct and complete. Correct any discrepancy before proceeding with the work.

3.02 INSTALLATION

A. Install site furnishings in accordance with manufacturer installation instructions and as indicated on the Contract Drawings. Install site furnishings plumb, level, square, in true alignment and firmly anchored without rocking. Construct footing leveling pads as needed for level installation.

B. Install bike lockers to allow for the door opening.

C. Bollards:

1. Anchor posts or pipe sleeve in concrete as shown. For permanent fixed bollards, fill solidly with concrete with minimum compressive strength of 2500 psi.

2. Bollard: Field painted as specified in Section 09900, Paints and Coatings.

END OF SECTION
SECTION 10200
STATION SHELTERS

PART 1 - GENERAL

1.01 DESCRIPTION
A. Section includes specifications for prefabricated station shelters for the following applications: Persons Needing Assistance (PNA) Shelters, Passenger Shelters, and Ticket Vending Machine (TVM) Shelters.

1.02 SUBMITTALS
A. Shop Drawings: Submit shop drawings of stations, including installation details, for Engineer’s approval.

B. Product Data: Submit manufacturers’ product data and maintenance instructions.

C. Samples: Submit the following samples for Engineer’s approval:
   1. Glass: ¼ inch thick safety tempered glass, clear
   2. Powder Coat and Bench Colors: Manufacturer’s color palette for Engineer’s approval

PART 2 – PRODUCTS

2.01 PRODUCTS
A. Shelters: Shelters listed below are products of Brasco International, Inc. See Caltrain Standard Drawing.
   1. PNA Shelter: Model No. MN510-C or Engineer approved equal
   2. Passenger Shelter: Model No. MN819-WC or Engineer approved equal
   3. TVM Shelter: Model No. MN819 or Engineer approved equal

B. Structural framing shall be dark bronze powder coated finish. Aluminum standing seam gable roof with smooth gable ends.

C. Shelter fasteners including anchors to substrate shall be vandal-proof.

D. Shelters shall contain:
   1. Engineered plastic (HDPE) bench with backrest. Finish – simulated wood appearance
   2. Two 20 Watt LED lamps with photocells
PART 3 - EXECUTION

3.01 INSTALLATION

A. Securely attach shelters to substrate, level and plumb.
B. Repair damaged finishes in accordance with manufacturer’s instructions.
C. Firmly attach Owner-furnish decal labels on shelters.

END OF SECTION
SECTION 10500
WHEEL CHAIR LIFT AND SHED

PART 1 - GENERAL

1.01 DESCRIPTION
A. Section includes specifications for ADA compliant mobile wheel chair lifts and accompanying bridge plate for accessing train cars.
B. Include with each lift a metal steel enclosure or shed for outdoor environment. See Caltrain Standard Drawings for details of the lift and shed.

1.02 SUBMITTALS
A. Product Data: Submit manufacturer product data including operation and maintenance instructions.
B. Provide sample of the gravity latch for the shed for approval by the Engineer.

1.03 DELIVERY

PART 2 - PRODUCTS

2.01 PRODUCTS
A. Wheelchair Lift: Model Mobilift/TX, as manufactured by Adaptive Engineering Inc., or Engineer approved equal.
B. Features: Lift capacity: 600 lbs. Manually operated and portable without electrical or hydraulic components. Automatically self leveling so it can be used on uneven ground. Lift height: 5 ft maximum. Width: 37.5 inches. Designed for exterior use. Vandal resistant.
C. Bridge plate: 36 inches long.
D. Wheelchair Shed: Hot dip galvanized steel construction for exterior use with vandal proof secure system.

PART 3 – EXECUTION

3.01 INSTALLATION
A. Secure the shed at the location as shown on the Contract Drawings. Store the wheel chair lift inside the shed.

END OF SECTION
SECTION 10900
RIGHT-OF-WAY SIGNAGE

PART 1 - GENERAL

1.01 DESCRIPTION

A. Section includes specifications for exterior signage including object markers, such as speed signs, mile post markers, whistling board and station one mile signs.

1.02 REFERENCE STANDARDS

A. American Society for Testing and Materials (ASTM International):
   2. B209 Specification for Aluminum and Aluminum-Alloy Sheet and Plate
   3. D635 Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position
   5. D4956 Specification for Retroreflective Sheeting for Traffic Control

B. California Manual on Uniform Traffic Control Devices (Federal Highway Administration MUTCD, as amended for use in California) (CMUTCD)

C. State of California, Department of Transportation (Caltrans), Standard Specifications:
   1. Section 56 Signs
   2. Section 75 Miscellaneous Metals

D. State of California, Department of Transportation (Caltrans), Standard Plans.

1.03 SYSTEM DESCRIPTION

A. Signage, unless otherwise noted, shall conform to Caltrans Standard Specifications, Section 56, Signs, and CMUTCD. Sign panels shall be furnished by the Contractor.

B. Owner will provide a “camera-ready” copy of the colored Caltrain™ logo.

1.04 SUBMITTALS

A. Shop Drawings: Show sizes and thickness of all members, types of materials, methods of construction and assembly, complete sign and framing dimensions including span length and post heights, hangers, brackets, anchorage,
relationship to surrounding work by other trades, shop finishes, sign designs, layouts, lettering (including letter spacing), and other pertinent details of fabrication and installation.

B. Manufacturer’s Data: Sign manufacturer’s descriptive data.

C. Samples: Samples of all materials under this Section, as follows:
   1. Of all colors proposed for use on all signs, at least 8 inches by 8 inches.
   2. Full-size paper proofs of all signs, marked with proposed colors.
   3. After approval of color match and lettering proofs, submit for approval one full size sign of each type, as selected by the Engineer, complete and ready for installation. Submit as many times as necessary until approval by the Engineer has been obtained. Sample sign, upon approval, shall serve as the standard to be equaled by all other work.
   4. Manufacturer’s color palette for fiberglass sign panels and frames for color selection.

D. Certification of Compliance: Certify that aluminum posts for fiberglass sign panels will withstand 100 mile per hour wind loading.

1.05 QUALITY ASSURANCE

A. Installation work under this Section shall be performed by experienced sign erectors.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Ship sign panels in such a manner as to ensure their arrival on the job site in an undamaged condition.

B. Deliver and store material in a manner to prevent cracking, chipping or stress of the components, and to prevent mechanical damage or weather damage.

1.07 WARRANTY

A. Provide a 5 year warranty against material defects.

PART 2 – PRODUCTS

2.01 NON-ILLUMINATED SIGN PANELS

A. Aluminum Sign Panels:
   1. Flat sheet aluminum sheeting conforming to ASTM B209, Alloy 6061-T6, 1/8 inch thick minimum.
   2. The sign panel shall be retroreflective prismatic in accordance with ASTM D 4956 Class III or higher. The sheeting shall be applied as
specified by the sheeting manufacturer to recommended, properly prepared flat surfaces without the necessity of additional adhesive coats on the reflective sheeting or application surface.

3. Application of all lettering, arrows, and other artwork shall be by photographic silk screen. Do not modify font or layout rules and the arrow/circle.

B. Fiberglass Reinforced Plastic Sign Panels:

1. Products: One of the following products and in compliance with the requirements specified herein: Fiber-Brite; Sequentia, "Polyplate"; Inteplast Group "InteCel" (0.5 inch for Post-Mounted CZ Signs, 48 inches or less), or Engineer approved equal.

2. The sign panel shall be retroreflective prismatic in accordance with ASTM D 4956 Class III or higher. The sheeting shall be applied as specified by the sheeting manufacturer to recommended, properly prepared flat surfaces without the necessity of additional adhesive coats on the reflective sheeting or application surface.

3. Plastic shall be stabilized to prevent the release solvents and monomers. The front and back surfaces of the laminate shall be clean and free of constituents and releasing agents that can interfere with the bonding of retroreflective sheeting.

4. Panel shall be weather resistant Grade II thermoset polyester laminate.

5. Color of fiberglass reinforced plastic panels shall be uniform gray.

6. Panels shall be minimum 0.135-inch thick.

7. Tolerances: Finished fiberglass reinforced plastic panel signs shall be flat within a tolerance of ±1/32 inch per linear foot when measured across the plane of the sign in all directions. The finished signs shall have an overall tolerance within ±1/8 inch of the specified dimensions.

8. Fabrication: Cut fiberglass reinforced plastic panels from a single piece of laminate. Pre-drill bolt holes. Fabricate true and smooth predrilled bolt holes, panel edges, and the front and back surfaces of the panels. The panel surfaces shall be free of visible cracks, pinholes, foreign inclusions, warping and wrinkles that can affect performance and serviceability.

2.02 TYPEFACE (TEXT)

A. Font shall be Helvetica medium with industry standard normal letter spacing.

B. Place type and symbols as shown on the Contract Drawings. Bring any design conflict in the manufacture and fabrication of the signage to the attention of the Engineer before proceeding.
2.03 SIGN FRAMES

A. Fabricate required steel framing, sign back bracing and support posts in accordance with Caltrans Standard Specifications, Section 75, Miscellaneous Metal.

B. Hot-dip galvanize steel framing, mounting components, hardware and appurtenances after fabrication and touch up as specified in Section 05500, Metal Fabrications, and with Caltrans Standard Specifications, Section 75, Miscellaneous Metal.

C. Frames for fiberglass sign panels: Extruded aluminum tubing conforming to the manufacturer’s requirements for each sign type. Finish shall be satin anodized in color selected by the Engineer.

2.04 FASTENINGS AND ANCHORS

A. Unless otherwise noted, design a complete system of fastenings and anchorage devices for the various signs, as required for attachment to the various supporting structures.

B. Straps and Saddle Brackets: Stainless steel conforming to the requirements of ASTM A167, Type 302 or 304, for mounting sign panels on electroliers, sign structure posts, and where shown on the Contract Drawings.

C. Theft and vandal proof bolts: Stainless steel with a chromium content of at least 16 percent and a nickel content of at least 8 percent.

D. Lag Screws, Bolts (Except Theft-Proof Bolts), Metal Washers and Nuts: Commercial quality steel, hot dip galvanized after fabrication in accordance with Caltrans Standard Specifications, Section 75, Miscellaneous Metal. Fiber washers shall be of commercial quality.

E. Fastenings and anchors for fiberglass sign panels shall conform to the sign panel manufacturer’s requirements for each sign type.

2.05 SIGN COLORS

A. Standard paint colors as manufactured by Dupont, or Engineer approved equal, and as follows:

<table>
<thead>
<tr>
<th>Color</th>
<th>Imron (spray)</th>
<th>Dulux(brush)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>68209UM</td>
<td>93-58209H</td>
</tr>
<tr>
<td>Yellow</td>
<td>6808U</td>
<td>93-6808</td>
</tr>
<tr>
<td>White</td>
<td>617U</td>
<td>93-21667</td>
</tr>
<tr>
<td>Black</td>
<td>69</td>
<td>93-005</td>
</tr>
</tbody>
</table>

B. For fiberglass sign panels, as selected from manufacturer’s color palette.
2.06 POSTS

A. Metal Posts (Aluminum Signs only): Metal posts shall be in accordance with Caltrans Standard Specifications, Section 56-2.02A, Metal Posts, with the following additional requirements:

1. Hot dip galvanize steel posts, mounting components, hardware and appurtenances after fabrication and touch up as specified in Section 05500, Metal Fabrications, or as specified in Caltrans Standard Specifications Section 75 – 1.05, Galvanizing.


B. Wood Posts: Wood posts shall be in accordance with Caltrans Standard Specifications, Section 56-2.02B, Wood Posts, with the following additional requirements:

1. Posts shall be 4 x 4 inches nominal size unless otherwise indicated on the Contract Drawings.

2. Preservative treat posts other than all heart redwood. Kiln dry prior to treatment

C. Aluminum Posts for Fiberglass Sign Panels: Extruded aluminum tubing conforming to the manufacturer’s requirements for each sign type. Finish shall be satin anodized. Design posts to withstand 100 mile per hour wind loading.

D. Object Marker: Type P, conforming to the details shown on Caltrans Standard Plan A73B.

PART 3 – EXECUTION

3.01 SIGN INSTALLATION

A. Install signs true, plumb, and level, where shown on the Contract Drawings. Do no field cutting of any sign work. Prevent bending and chipping signs. Exercise extreme care in all handling and stacking of signs to avoid bending or chipping. Replace chipped and bent sign panels. Exact locations of signs will be confirmed by the Engineer in the field.

B. Rigidly anchor work to the supporting construction, as shown on the approved shop drawings. Conceal fastenings, except those which anchor supporting members to structure. Fabricate and erect supporting members and securely attach to the various structures in accordance with Caltrans Standard Specifications, Section 75, Miscellaneous Metal.

C. Subsequent to erection, if required by the Engineer, exterior signs may be required to be covered until their actual use is required. Material used to temporarily cover any sign panel shall effectively conceal the message and be non-injurious to the panel, its finish, and its structural integrity.
3.02 POST INSTALLATION

A. Install posts in accordance with Caltrans Standard Specifications, Section 56-2.03, Construction, with the following additional requirements:

1. The remaining space around the post in the post holes shall be backfilled with concrete.

2. Dispose of surplus excavated material as specified in Section 02300, Earthwork.

3. Repair any spalling, chipping or cracking of concrete structures. Obtain the Engineer’s approval of repair method.

4. Unless otherwise noted, do not paint wood posts and blocks.

1. Touch-up galvanized metal as specified in Section 05100, Metal Fabrications, or as specified in Caltrans Standard Specifications Section 75 – 1.05, Galvanizing.

3.03 REMOVING, RELOCATING, REINSTALLING AND SALVAGING EXISTING SIGNS

A. Remove, relocate, and salvage existing signs in accordance with Section 02220, Demolition, as augmented herein.

B. Remove and re-install existing signs in new locations as shown on the Contract Drawings. Provide all necessary components required for erecting the existing sign in its new location, including support framing, hardware, post, post holes and concrete. Obtain Engineer’s inspection for defects and approval of signs to be relocated prior to re-installation.

C. Where existing Milepost signs at one-tenth mile intervals need to be removed to facilitate the Contractor’s construction operations, remove and reinstall, or remove and replace with new signs. Relocate Milepost signs to a new location if the existing location changes due to new track alignment.

D. Salvaging of signs shall include removing, disassembling, preparing, marking, bundling, packaging, tagging, hauling and stockpiling. Signs to be salvaged shall not be removed until their use is no longer required as determined by the Engineer. Salvaged materials shall be cleaned of all foreign materials and pressed flat before delivery to the Engineer.

E. Existing posts, which support signs that are to be salvaged, shall become the property of the Contractor and shall be disposed of outside the work site. Refer to General Provisions 7.16, Disposal of Material Outside of the Work Site.

F. Protection and cleanup requirements for the new signs shall apply to the existing signs once that have been reinstalled.
3.04 PROTECTION AND CLEANING

A. Protect and maintain completed sign panels in good condition, free from dirt, scratches, hand marks or other blemishes.

B. Clean surfaces of sign work as recommended by the sign manufacturer after installation and keep in a condition satisfactory to the Engineer.

C. Remove and replace defective work, including that exhibiting cracked, chipped, scratched, abraded, or otherwise damaged finishes, with work conforming to the specified requirements.

3.05 DISSIMILAR MATERIALS

A. Separate aluminum surfaces in contact with or in close proximity to non-compatible metals or concrete with non-absorptive tape, coat of heavy-bodied bituminous paint, or zinc chromate primer.

END OF SECTION
SECTION 15000
BASIC MECHANICAL REQUIREMENTS

PART 1 – GENERAL

1.01 DESCRIPTION
A. Section includes basic mechanical requirements to complete the work as shown on the Contract Drawings and as specified herein. Provide all work and miscellaneous items, not specifically mentioned by reasonably inferred for complete operable systems.

1.02 DESIGN REQUIREMENTS
A. Design anchorage and secure mechanical equipment in accordance with applicable code. In addition, design anchorage and secure equipment to withstand a lateral force of 0.6 times the weight of the equipment, if such requirement is more stringent.

1.03 SUBMITTALS
A. General: The following are in addition to the submittal requirements in the individual Division 15 Sections.

1. Material list
2. Manufacturer’s data: Certified by the factory’s corporate officer
3. Shop drawings: As required under the general requirements specified in this Section and as required under individual Division 15 Sections.
4. Calculations: Structural calculations showing that equipment anchorage will withstand applicable lateral force. Submit other calculations as specified in individual Sections. Calculations shall be signed and sealed by professional engineer licensed in the State of California.

B. Material List:
1. Submit a complete list of material and equipment proposed for the job, including manufacturer’s name.
2. Reference all listings to paragraphs to which they are applicable.
3. List only name of manufacturer. Catalog numbers and performance data not to be included at this time.
4. Submit complete list of materials and equipment, even if same as specified or shown on the Contract Drawings.
C. Manufacturer’s Data:

1. Submit after review of material list. Include data for all material and equipment that will be installed.

2. Include complete catalog information such as construction, capacity, types, pump curves, sizes, finish, mounting methods and operating noise levels. Provide factory certified submittals.

3. Reference all listings to paragraphs to which they are applicable and submit in brochure form.

4. For any material specified as ASTM, Federal Specifications, or industry standards, furnish the manufacturer’s certification that the material furnished for the work does in fact equal or exceed such requirements.

D. Submittals shall be factory or manufacturer certified.

E. Shop Drawings: Submit the following at 3/8 inch scale or larger, in order to show all pertinent features of the equipment and method of installation and connection to the work. These requirements are in addition to those specified in Section 01300, Submittals and Deliverables.

1. Equipment layout drawings to scale, including equipment, ductwork, piping, including plumbing, accessories, showing clearance for operating and servicing. Indicate bottom elevations for all equipment. Indicate all existing equipment and ductwork, piping, and point of connection of new work.

2. Piping diagrams of all major systems, showing all equipment, accessories, and sizes.

3. Wiring diagrams shall include all low and line voltage wiring and equipment.

F. Submit Operations and Maintenance Manuals (O&M Manuals) as specified in Sections 01730, Operations and Maintenance Manuals, all mechanical equipment and systems in.

1.04 COORDINATION

A. Perform Work in cooperation with all other trades in order to secure the best arrangement of the Work. Make no changes in the work without the written approval of the Engineer.

B. Verify that utility requirement characteristics of operating equipment are compatible with utilities. Coordinate work of various sections having interdependent responsibilities for installing, connecting to, and placing in service, such equipment.

C. Coordinate space requirements and installation of mechanical and electrical work, which are indicated diagrammatically on the Contract Drawings. Follow
routing shown for pipes, ducts, and conduit as closely as practicable. Place runs parallel.

D. Scaled and figured dimensions are approximate. Before proceeding with any work, carefully check and verify dimensions.

E. Equipment size and locations shown on the Contract Drawings are based on the dimensions of a particular manufacturer or dimensions of typical equipment of class indicated. Check the Contract Drawings, as well as actual equipment dimensions, and ensure that the equipment will fit into the spaces provided. If required for coordination with other work or if requested by the Engineer, prepare shop drawings indicating a suitable arrangement of proposed equipment.

1.05 DELIVERY, STORAGE, AND HANDLING

A. For exterior storage of fabricated products, place on sloped supports, above ground.

B. Provide off-site storage and protection when site does not permit on-site storage or protection.

C. Store loose granular materials on solid flat surfaces in a well-drained area. Prevent mixing with foreign matter.

PART 2 – PRODUCTS

2.01. MATERIALS - GENERAL

A. Provide materials, including auxiliary equipment, unless otherwise noted.

B. Materials shall be of the quality specified. Materials or equipment damaged in shipment or otherwise damaged prior to installation shall not be repaired at the job site, but shall be replaced with new material.

C. Verify that items specified by manufacturer’s name and product number meet the requirements of the Specifications. Do not assume when a manufacturer’s name and product name or number appears in these Specifications that the manufacturer and standard catalogue item meets the requirements of the Specifications.

D. Equipment installed as part of the Work shall have local representation, local factory authorized service, and a local stock of repair parts, unless an exception is approved by the Engineer.

E. Manufacturer for each type of material shall be the same throughout the Work.

2.02 MATERIALS

A. Sleeves for Walls and Slabs: Schedule 40, galvanized steel pipe.
B. Protect metallic structures against corrosion. Provide equipment with manufacturer’s standard rust-inhibiting treatment and the finish, unless otherwise specified.

C. Ferrous fittings, such as anchors, bolt rods nuts and miscellaneous parts, except stainless steel fittings, shall be hot dip galvanized.

D. Sealing Compound: An incombustible, permanently plastic, waterproof non-staining compound leaving a finished smooth appearance.

E. Backer: An incombustible fibrous glass recommended for specified application.

PART 3 – EXECUTION

3.01 GENERAL

A. Prior to commencing work of this Section, inspect the installed work of other trades and verify that such work is complete to the point where this installation may commence. Verify that the completed installation will conform with all pertinent codes and regulations, the Contract Drawings, approved submittals, and the referenced standards. In the event of discrepancy, notify the Engineer immediately and proceed as directed.

B. Follow the manufacturers’ published directions in installation of piping, equipment, and material, except when otherwise required in the Contract Documents.

C. Install and use material and equipment only in a manner for which it is approved and manufactured.

D. Do not use aluminum in contact with earth and, where connected to dissimilar metal, protect with suitable fittings and treatment.

E. Provide anchor bolts for all equipment placed on concrete pads and slabs. Anchor bolts shall be the size and number recommended by the equipment manufacturer, complying with structural calculations, and located by means of templates.

3.02 SLEEVES AND OPENINGS

A. Provide sleeves for each pipe passing through slabs and walls, whether shown or not.

B. Set all pipe sleeves and inserts in place before concrete is poured. Coordinating the placing of these items to avoid delaying concrete placing operations.

C. Sleeves for non-insulated pipe shall be two pipe sizes larger than pipe passing through or a minimum of 1/2 inch clearance between inside the sleeve and outside pipe.
D. Length of sleeve as follows:

<table>
<thead>
<tr>
<th>Sleeve Locations</th>
<th>Sleeve Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slabs</td>
<td>Equal to depth of slab construction including finish.</td>
</tr>
<tr>
<td></td>
<td>Extend minimum of 2 inches above floor level in finished area and in pipe areas.</td>
</tr>
<tr>
<td>Roofs</td>
<td>Equal to depth of slab construction including insulation.</td>
</tr>
<tr>
<td>Walls</td>
<td>Equal depth of construction and terminated flush with finished surfaces.</td>
</tr>
</tbody>
</table>

E. Seal space between the pipe and the sleeve under all escutcheons with a sealing compound or pack with backer to within 1/2 inch of both wall faces and provide sealing compound on both faces.

3.03 REPAIR AND RESTORATION

A. Repair, grout, refinish, and apply touch-up paint, as necessary to make the facility like new, where structures are affected by the installation of mechanical systems.

3.04 ADJUSTMENT, CLEANING, AND OPERATION PRIOR TO COMPLETION

A. When mechanical or electrical equipment is operable and with the written permission of the Engineer, the Contractor may operate equipment. Supervise such operation. The warranty period shall, however, not commence until the date specified in General Provisions 4.6, Guaranty of Work.

B. Regardless of whether equipment has or has not been operated, clean and adjust equipment before Final Acceptance. Replace filters if equipment has been operated and as otherwise required in the Contract Documents.

3.05 TRAINING

A. When training is required under other Sections of Division 15, provide the services of manufacturer's qualified factory trained field service engineer for a one, eight hour working day session at the site to instruct Owner personnel in the operation and maintenance of the pump units. This eight hour working day session for training is separate and independent of the requirements set forth for the manufacturer's representative for start-up and testing. Utilize operation and maintenance manuals as text for instruction.

END OF SECTION
SECTION 15150
PLUMBING

PART 1 – GENERAL

1.01 DESCRIPTION

A. Section consists of furnishing and the installation of plumbing systems, complete with pipe and fittings, appurtenances, components and other accessories as shown on the Contract Drawings and specified herein.

1.02 REFERENCE STANDARDS

A. American Society of Mechanical Engineers (ASME):
   1. B1.1 Unified Inch Screw Threads
   2. B16.1 Gray Iron Pipe Flanges and Flanged Fittings (Classes 25, 125, and 250)
   3. B16.3 Malleable Iron Threaded Fittings

B. American National Standards Institute (ANSI)
   1. A13.1 Scheme for Identification of Piping Systems

C. American Society for Testing and Materials (ASTM International):
   1. A53 Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
   2. A74 Specification for Cast Iron Soil Pipe and Fittings

D. Sheet Metal and Air Conditioning Contractors National Association (SMACNA)
   1. SEIS Seismic Restraints: Guidelines for Mechanical Systems

1.03 SUBMITTALS

A. Refer to Section 15000, Basic Mechanical Requirements, for additional submittals.

B. Product Data: Submit technical literature covering drawings and details of equipment, fixtures and accessories furnished under this Section.

1.04 COORDINATION

A. Coordination: Coordinate plumbing with the other mechanical work, and all underground piping work in accordance with the requirements of this Section. Coordinate plumbing with concrete work and masonry work where pipe sleeves may be required.
B. Codes and Regulations: Where larger sizes are required by the applicable code, the more stringent requirements shall prevail.

C. Should field conditions or other causes necessitate rearrangement of plumbing work, obtain Engineer’s approval of the proposed arrangement before work is started.

D. Space Limitation: Keep plumbing work within the spaces indicated in the design to receive such work. Conceal piping in finished spaces. Should other openings or spaces be necessary, notify the Engineer and make such openings or spaces.

PART 2 – PRODUCTS

2.01 GENERAL

A. Furnish and install materials and accessories as shown on the Contract Drawings and as required, complete with components, trims and miscellaneous facilities.

B. Threads: Conforming to ASME B1.1.

2.02 PIPE

A. Pipe: ASTM A74, cast iron, Class 150

B. Pipe: ASTM A53, galvanized or black iron pipe, threaded

C. Flanges: ASME B16.1, cast iron, Class 125, threaded

D. Fittings: ASME B16.3

2.03 GATE VALVES

A. Iron Body, Bronze Trim, Rising Stem and Handwheel, OS&Y, Single Wedge, Flanged Ends, Class 125.

2.04 CHECK VALVES

A. Iron Body, Bronze Trim, Swing Disc, Renewable Disc and Seat, Flanged Ends, Class 150.

2.05 DIELECTRIC CONNECTIONS

A. Joints between ferrous and non-ferrous piping shall be made with dielectric insulating unions, suitable to withstand the pressure, temperature and characteristics of service. Where flanged dielectric joints are required, special insulating gaskets, sleeves, and washers shall be provided to ensure proper connection.

2.06. HANGERS AND SUPPORTS

A. Hangers and supports shall be capable of adjustment after piping is erected. Hanger and support shall be standard product and type best suited for the
service or condition required, as manufactured by Superstrut, Grinnell, or Engineer approved equal.

B. Hanger spacing and seismic restraints shall be as required in SMACNA SEIS.

2.07 PIPING IDENTIFICATION

A. Band or Tape: Permanent type linear polyethylene, fiberglass or mylar snap-on bands or pressure-sensitive, color-coded tapes with contrasting lettering to identify each piping service per ANSI A13.1.

B. Flow arrow shall be of the same color as pipe service.

2.08 UNDERGROUND CORROSION PROTECTION

A. Corrosion Protective Tape: Type suitable for application specified. Furnish in widths as recommended by the manufacturer as best suited for pipe size being wrapped.

B. Primer: As required by tape manufacturer.

PART 3 – EXECUTION

3.01 GENERAL PIPING WORK

A. Arrange and provide for the necessary openings in walls and the proper roughing-in of the plumbing work. Rough in shall be exact to measurements furnished by the manufacturer.

B. Clean pipe, fittings, and valves of grease, dirt, and scale before installation. Keep temporary pipe openings closed during the performance of the Work. Ream pipe ends smooth and remove all burrs before installation.

C. Cut pipe accurately to measurements taken on the job. Install offset connections for alignment of vertical to horizontal piping and where required to make a true connection. Bent or sprung pipe is not acceptable. Piping connections shall have unions where necessary for replacement and repair of equipment. Install gate valves where shown and where necessary for proper operation and service. Install vertical piping plumb and horizontal piping parallel to walls of the storm water lift system structure and similar structures. Support piping as required to prevent vibration. Coordinate anchor supports with pre-cast concrete structure fabrications.

D. Provide venting of plumbing work as required by applicable code and as shown on the Contract Drawings.

E. Threaded joints shall be full and clean cut. Ream ends of pipe to the full inside diameter, and not more than three threads exposed beyond fittings. Make-up joints tight with graphite joint compound. Use manufacturer approved pipe compound on screwed joints.
F. Factory prepare as much of the plumbing system internal to the storm water lift system as possible. Field install plumbing system in accordance with manufacturer’s recommendations and this Section.

G. Finally adjust hangers, both in the vertical and horizontal directions.

H. Coordinate the plumbing system with the electrical work other trades associated with the installation and operation of mechanical equipment.

I. Sleeves: As specified in Section 15000, Basic Mechanical Requirements.

3.02 PIPING IDENTIFICATION

A. Apply piping identification bands or tapes to identify each piping service per ANSI A13.1.

B. Point arrow in the direction of flow and apply at location with maximum visibility.

3.03 UNDERGROUND CORROSION PROTECTION

A. Spiral wrap carbon steel and copper pipe installed underground or below concrete slabs with corrosion protective tape to a 20 mil thickness. Thoroughly clean, dry, and remove sharp points, and then prime before wrapping.

B. Apply tape tightly with 1/2 inch minimum overlap, free from wrinkles and voids. Use wrapping machine as recommended by tape manufacturer.

END OF SECTION
SECTION 15550
STORM WATER LIFT STATIONS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Section includes specifications for packaged storm water pump lift stations.

1.02 REFERENCE STANDARDS

A. American Society for Testing and Materials (ASTM International):
   1. C443 Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
   2. C478 Specification for Precast Reinforced Concrete Manhole Sections

B. State of California Department of Transportation Bridge Design Specifications (Caltrans)

C. Standard Specifications for Public Works Construction (SSWPC):
   1. Section 208-6 Pipe to Manhole Flexible Couplings

1.03 DEFINITIONS

A. H-20 loading: As defined in Caltrans Bridge Design Specifications.


1.04 PERFORMANCE REQUIREMENTS

A. Operating Conditions: Each pump shall be capable of delivering scheduled flow at scheduled dynamic head. All openings and passages shall be large enough to permit the passage of a sphere three (3) inches in diameter.

1.05 SUBMITTALS

A. Refer to Section 15000, Basic Mechanical Requirements, for additional submittals.

B. Product Data:
   1. Dimensional drawings of lift station drawn to scale indicating components and connections to other equipment and piping.
   2. Indicate pump type, capacity, and power requirements.
3. Certified pump curves showing pump performance characteristics with pump and system operating point plotted. Include net positive suction head (NPSH) curve and total dynamic head (TDH) calculations.

4. Include a performance chart for motor showing curves for torque, current, power, factor, input/output kW and efficiency. This chart shall also include data on starting and no-load characteristics.

5. Mass moment of inertia calculations for the impellers upon the Engineer’s request.

6. Indicate materials of construction.

7. Electrical characteristics and connection requirements.

C. Shop Drawings: The shop drawings shall include the following:

1. Dimensions of sump manhole, equipment, anchors, steps or ladders, pipe supports, attachments, lifting points, tappings, drains, piping, valve, fittings, float switches and access cover and locking hardware.

2. Structural calculations and shop drawings for precast reinforced concrete valve vault manhole and other precast drainage structure components.

3. Any fabricated items not detailed on Contract Drawings.

1.06 DELIVERABLES

A. Submit certificates of factory and manufacturer’s representative's on-site inspection, testing, and approval to the Engineer.

B. Operation and Maintenance Data: Submit as specified in Sections 01700, Contract Closeout, and 15000, Basic Mechanical Requirements. Include operation, maintenance, and inspection data, replacement part numbers and availability, and service depot location and telephone number.

1.07 QUALITY ASSURANCE

A. Notify the Engineer prior to and perform all testing during progress of the work in the presence of the Engineer.

B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this Section with minimum ten years experience.

C. Structural calculations and shop drawings for precast reinforced concrete valve vault manhole and other precast drainage structure components shall be sealed and signed by a registered structural engineer licensed in the State of California.

1.08 WARRANTY

A. Warranty: Submit five year manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.
PART 2 - PRODUCTS

2.01 GENERAL

A. Equipment and appurtenances for each packaged storm water lift station shall include two pumps; valves; internal piping; central control panel with circuit breakers; motor starters; level controls; electrical controls and wiring; electrical service connection; precast concrete valve pit vault; concrete work; and miscellaneous appurtenances.

B. Provide pumps with manufacturer's name, model number, and rating/capacity clearly identified.

C. Provide pumps complete with the following features and appurtenances:

1. Submersible, centrifugal, duplex arrangement, non-clog pumps.

2. Precast reinforced concrete valve vault manhole structure, galvanized steel steps, pipe supports, and similar items.

3. Pump guide rails shall be custom stainless steel construction and shall allow pump lift-out assembly and pump to move from bottom of guide to top of guide without binding. The lift-out assembly shall be easily removable from the top of rail.

4. Liquid level sensors, control panel complete with starters, alternator, controls, and alarm lights.

5. Plumbing: Provide each pump discharge with a check valve and a gate valve.

6. The motor and pump shall be designed and assembled by the same manufacturer.

7. The motor and cable shall be capable of continuous submersion underwater without loss of watertight integrity.

2.02 SUBMERSIBLE CENTRIFUGAL NON-CLOG PUMPS

A. Pumps: Submersible centrifugal non-clog type for wet pit installation, capable of continuous submersion to the maximum depth indicated in the Contract Documents.

B. When lowered on its guide rail, each pumping unit shall be automatically and firmly connected to a discharge fitting permanently mounted on the discharge pipe. Sealing of the discharge connection by means other than metal to metal contact of the pump discharge flange and the discharge fitting will not be acceptable. The guide rail system shall be furnished, complete by the lift station manufacturer or in accordance with manufacturer's recommendations. Each pump shall be equipped with a lifting chain and power cable of sufficient strength and length to permit easy removal for inspection or repair.
2.03 MOTOR

A. Pump Motor: Induction type with a squirrel cage rotor, shell type design, housed in an air filled, watertight chamber, NEMA B type. The stator windings and stator leads shall be insulated with moisture resistant Class F insulation rated for 311 degrees F. The stator shall be dipped and baked three times in Class F varnish and shall be heat-shrink fitted into the stator housing. The motor shall be designed for continuous duty handling pumped media of 104 degrees F and capable of up to 15 evenly spaced starts per hour. The rotor bars and short circuit rings shall be made of cast aluminum. Thermal switches set to open at 260 degrees F shall be embedded in the stator lead coils to monitor the temperature of each phase winding. These thermal switches shall be used in conjunction with and supplemental to external motor overload protection and shall be connected to the control panel.

B. The combined service factor shall be a minimum of 1.15. The motor shall have a voltage tolerance of plus or minus 10 percent. The motor shall be designed for operation up to 104 degrees F ambient and with a temperature rise not to exceed 144 degrees F.

C. Motors shall be sufficiently cooled by the surrounding environment or pumped media. A water cooling jacket shall not be required.

D. The motor horsepower shall be adequate so that the pump is non-overloading throughout the entire pump performance curve from shut-off through run-out.

E. Motors shall be capable of continuous submergence to a depth of 65 feet without loss of watertight integrity.

2.04 ELECTRICAL CABLE AND PROTECTION

A. Size power cable in accordance with the National Electric Code (NEC) and Insulated Cable Engineers Association (ICEA) standards with sufficient length to reach the junction box above sump pit without the need of any splices. The outer jacket of the cable shall be oil resistant chloroprene rubber.

B. The cable entry seal design shall include specific torque requirements to ensure a watertight and submersible seal. The cable entry shall consist of a single cylindrical elastomer grommet, flanked by washers, all having a close tolerance fit against the cable outside diameter and the entry inside diameter and compressed by the body containing a strain relief function, separate from the function of sealing the cable.

C. All starters shall incorporate thermal switches in series to monitor the temperature of each phase winding. At 260 degrees F, the thermal switches shall open and stop the motor.

2.05 BEARINGS

A. The pump shaft shall rotate on two bearings. Motor bearings shall be permanently grease lubricated. The upper bearing shall be a single deep groove
ball bearing. The lower bearing shall be a two row angular contact bearing to compensate for axial thrust and radial forces.

### 2.06 MECHANICAL SEAL

**A.** Provide each pump with a tandem mechanical shaft seal system consisting of two totally independent seal assemblies. The seals shall operate in an oil reservoir that hydrodynamically lubricates the lapped seal faces at a constant rate. The lower, primary seal unit, located between the pump and the oil chamber, shall contain one stationary and one positively driven rotating tungsten-carbide ring. The upper, secondary seal unit, located between the oil chamber and the motor housing, shall contain one stationary ceramic seal ring and one positively driven rotating carbon seal ring. Each seal interface shall be held in contact by its own spring system. Each pump shall be provided with an oil chamber for the shaft sealing system.

### 2.07 PUMP SHAFT

**A.** Pump motor shaft shall be the same unit. The pump shaft is an extension of the motor shaft. Coupling shall not be acceptable. The pump shaft shall be stainless steel.

### 2.08 IMPELLER

**A.** Impellers: Gray cast iron, Class 35B, dynamically balanced, double shrouded non-clogging design having a long through outlet without acute turns. The impellers shall be capable of handling solids, fibrous materials, heavy sludge and other matter found in storm water. Impellers shall be retained with an allen head bolt and shall be capable of passing a minimum 3 inch diameter solid. All impellers shall be coated with alkyd resin primer.

### 2.09 WEAR RINGS

**A.** A wear ring system shall be used to provide efficient sealing between the volute and suction inlet of the impellers. The wear ring shall be stationary and made of brass, which is drive fitted to the volute inlet.

### 2.10 VOLUTE

**A.** Pump Volutes: Single-piece gray cast iron, Class 30, non-concentric design with smooth passages large enough to pass any solids that may enter the impeller.

### 2.11 PIPING

**A.** Piping associated with the plumbing system of the storm water lift station and its discharge pipe shall be ductile iron with mechanical joints for buried service and galvanized steel for exposed service in the sump and the valve vault. Piping shall be in accordance with the requirements specified under Section 15150, Plumbing, and the manufacturer’s recommendations.

**B.** The pump discharge piping embedded in concrete shall be welded steel with flanged ends, hot dip galvanized after fabrication.
C. Size and type of inlet and outlet pipe varies. Refer to Contract Drawings and Section 02630, Storm Drainage System, for the requirements of inlet and outlet piping at sump manhole.

2.12 ELECTRICAL CONTROLS

A. Design standard duplex control panel to operate two submersible pumps based on wet well level monitored by level sensors. There shall be three (3) level sensors required for automatic operation of duplex pump station and (1) level sensor for high level alarm. The controls shall be float operated, duplex, with corrosion resistant floats to alternate operation of pumps and cut-in the second pump on rising level or lead pump failure. Provide additional set of wired terminals for future wiring of a remote alarm circuit.

B. The NEMA 1 control pump panel shall include the following:

1. Integral fused main switch
2. Pump short circuit protection
3. Pump overload protection
4. Pump direct on-line contactors
5. Two (2) sets start capacitors and two (2) sets run capacitors
6. Control transformer
7. Control transformer primary and secondary protection
8. Electromechanical and solid state logic components for interface with wet well level sensors, built-in pump sensors and selected standard options.
9. Pump and control terminal blocks
10. Panel mounted pilot lights and operators
11. NEMA 1 padlock enclosure and mounting components
12. Intrinsically safe relays for float circuits
13. High water alarm: Flashing light (red), pump No. 1 operating light (green), and pump No. 2 operating light (green) to be mounted on controller enclosure door.
14. H-O-A switches and status transformer type pilot lights
15. Utility 120 volts duplex receptacle fed from separate internal 1 Kva transformer
16. Elapsed time meter
17. Lightning suppressor
18. Remote light contacts
19. Individual pump starters with "soft start" modules and breakers
20. Alternator relay and override relay
21. Front of panel reset push-button

C. All of the items shall be UL approved and provided with requirements as specified hereinafter.

D. Sequence of operation of duplex controls shall be as follows:

1. When water level in pump pit reaches level sensors No. 2 (lead pump start sensor), the alternator provided for charging pump No. 1 and pump No. 2 duty (lead-lag alternating) will change its state and lead pump contactors will be energized. If water level continues to rise and reaches level sensor No. 3 (lag pump start sensor), the lag pump contactors will be energized until water level drops to level sensor No. 1 (pump's stop sensor).

2. Auxiliary contacts of pump circuit breakers shall be introduced into the circuitry in such a way that pump's contactors will be de-energized if circuit breaker trip condition occurs.

3. Auxiliary contacts of thermal overload relays shall be introduced into the circuitry so that pump's contactors are de-energized should a motor overload condition occur.

4. Pump motor windings thermal switch shall be introduced into the circuitry via a control relay so that a pump's contactor is de-energized should high temperature of motor windings occur. It shall not be possible for pump to restart automatically but front of panel reset push-button shall be provided for manual clearing of the fault.

5. If the inflow to the station is greater than the combined capacity of both pumps, the liquid levels will rise to the High Level Sensor No. 4 and send a signal to red alarm light.

6. Flashing red light alarm trouble light indicates any trouble or failure of pumps to drain wet well.

### 2.13 PRECAST REINFORCED CONCRETE VALVE VAULT MANHOLE

A. Reinforced concrete sump manhole shall conform to ASTM C478 and the applicable material and installation requirements of Sections 02630, Storm Drainage System, and 03300, Cast-in-Place Concrete.
B. Ground Surface Elevation: As indicated in the Contract Documents.

C. Ground Water Table Elevation: As indicated in the Contract Documents.

D. Static Loads & Dynamic (Seismic) Loads: Refer to Geotechnical Investigation Report.

E. Uplift: Refer to the Buoyancy Safety Factor specified in the Contract Documents and to contract-specific Geotechnical Investigation Report.

F. Maximum Bearing Pressure: 4000 psf.

G. Excavate and perform backfill operations for valve vault manhole as specified in Section 02300, Earthwork. Unless otherwise noted, place 18 inch deep crushed gravel over the bearing soil to provide a firm-bearing surface for the manhole foundation.

H. Pipe to Precast Reinforced Concrete Sump Flexible Couplings: Shall conform to SSWPC Section 208-6. Couplings shall resist mild exposure to petroleum products.

I. Joints shall be bell and spigot, single rubber O-ring gasketed, conforming to ASTM C443.

J. Access cover shall be cast iron and designed for H20 loading with lockable hardware.

K. Exterior surfaces of the manhole structure shall receive two coats, 7 mils per coat of "Kop-Coat" Bitumastic (Coal Tar) Super Service Black Coating System as manufactured by the Carboline Company, or Engineer approved equal.

L. Provide knockouts in top slab of precast concrete structure to facilitate installation of electrical conduits, vent piping, and similar protrusions. Coordinate number and size of knockout requirements with storm water lift system equipment. Do not use access cover to facilitate the above.

2.14 PUMP CONTROL/ELECTRICAL ROOM

A. Light for Outside Wall of Electrical Room: Provide exterior red light with vapor proof enclosure. Refer to Electrical Controls Article herein. This light shall flash indicating any trouble or failure of pumps to drain wet well.

2.15 VALVE ACCESS HATCHES

A. The frame shall be of a single leaf design for H-20 loading and of sizes as shown on the Contract Drawings or the approved shop drawings.

B. Hatch: Extruded aluminum with an integral anchor flange and seat. Equip with a flush aluminum drop handle which does not protrude above the cover and an automatic hold open arm with red vinyl grip on a release handle. Hinges shall be all stainless steel with tamper proof stainless steel bolts and nuts, and be removable for maintenance after the access door is cast in place. Access door
shall be furnished with mill finish, cable holder, holes for cable holder and guide bracket. Aluminum surfaces which will be in contact with concrete shall be coated with “Bitumastic 300M” as manufactured by Kop-Coat or Engineer approved equal.

C. Equip access hatch with locking assembly consisting of self latching stainless slam lock and with a recessed hasp so that it can be locked with a padlock. The assembly shall not create obstruction or hazard for pedestrian traffic.

2.16 PUMP ACCESS HATCH

A. Access Hatch: Dual leaf design for H20 loading and of a size as shown on the Contract Drawings or the approved shop drawings.

B. Hatch: Extruded welded steel with an integral anchor flange and seat. Equipped with a flush steel drop handle, which does not protrude above the cover and an automatic hold open arm with red vinyl grip on a release handle. Hinges shall be all stainless steel with tamper proof stainless steel bolts and nuts, and be removable for maintenance after the access door is cast in place. Access door shall be furnished with slip resistant galvanized diamond plate steel, Torsion spring assisted access door with hold open attachments. All parts shall be hot dipped galvanized. The walking surface shall be non-slip and rated for pedestrian service.

C. Equip access hatch with locking assembly consisting of self latching stainless slam lock and with a recessed hasp so that it can be locked with a padlock. The assembly shall not create obstruction or hazard for pedestrian traffic.

2.17 SOURCE QUALITY CONTROL

A. Perform tests to verify operation of electrical circuits and devices prior to shipment.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Ensure pumps operate at specified system fluid temperature without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within 25 percent of mid-point of published efficiency curve.

B. Coordinate the size of the precast concrete manhole sump structure with the storm water lift station system equipment, including but not limited to pumps, plumbing and electrical components. Ensure that there is adequate space within the structure to remove both pumps and to access the structure to perform periodical maintenance.

C. Install plumbing and electrical components of the storm water pump system in accordance with Section 15150, Plumbing, and applicable Sections of Division 16, Electrical.
3.02 START-UP, TESTING AND INSPECTION

A. Provide services of manufacturer’s representative on-site to assist with the start-up, testing, and inspection after the packaged storm water pump system has been installed.

B. The manufacturer’s representative test shall include:

1. Megger starter and power cables.
2. Check seal lubrication.
3. Check for proper rotation.
4. Check power supply voltage.
5. Measure motor operated load and no load current.
6. Check level control operation and sequence.
7. Single pump and dual pump operation test on manual and automatically as directed by the level control system.

3.03 FIELD QUALITY CONTROL AND INSPECTION

A. Pressure test entire assembly (pump discharge piping) prior to embedding in concrete.

B. After completion of the work of this Section and with the agreement of the Engineer, place storm water pump system in operation. Acceptance will not be made until the system has operated satisfactorily for a period of not less than 30 days from the date designated by the Engineer. This test period shall be included with the specified contract time. Operation of the system shall not in any way be construed as an acceptance of the system, or any part of it, or as a waiver of any of the provisions of this Contract. The Contractor shall be responsible for the system during this period of operation. Make any adjustments or repairs which may be required and remedy defects or damages which may occur. The Owner will pay the electrical energy cost consumed by the system during this trial operation.

3.04 TRAINING

A. Provide training for Owner personnel as specified in Section 15000, Basic Mechanical Requirements.

END OF SECTION
PART 1 - GENERAL

1.01 DESCRIPTION

A. Section includes requirements for roof mounted, self-contained units, with electric cooling, and electric or reverse refrigeration cycle (heat pump) heating and related controls; including:

1. Packaged rooftop unit
2. Controls
3. Remote panel
4. Roof mounting frame and base
5. Maintenance service

1.02 REFERENCES

A. Air Conditioning and Refrigeration Institute (ARI)
   1. 210/240 Performance Rating of Unitary Air-Conditioning and Air-Source Heatpump Equipment
   2. 270 Sound Rating of Outdoor Unitary Equipment

B. National Fire Protection Association (NFPA):
   3. 90A Installation of Air-Conditioning and Ventilation Systems

1.03 SUBMITTALS

A. Product data and schematic layouts showing condensing units, cooling coils, refrigerant piping and accessories required for complete system. Include complete pipe sizing data.

1. Include rated capacities, dimensions, weights, accessories, required clearances, electrical requirements, wiring diagrams and location and size of field connections.

B. Manufacturer’s installation instructions

C. Operation and maintenance manual (O&M Manual)

1.04 MAINTENANCE SERVICE

A. Furnish complete service and maintenance of packaged rooftop units for one year from date of substantial completion.
B. Provide maintenance service with a two month interval as maximum time period between calls. Provide 24-hour emergency service on breakdowns and malfunctions.

C. Include maintenance items as outlined in manufacturer’s operating and maintenance data including minimum of six filter replacements, minimum of one fan belt replacement and controls checkout, adjustments and recalibrations.

D. Submit copy of service call work order or report and include description of work performed.

1.05 EXTRA MATERIALS

A. Provide one set of filters.

1.06 WARRANTY

A. Provide five-year manufacturer’s material replacement warranty for compressor.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Carrier Corp.
B. AAON, Inc.
C. Trane Co.
D. Or Engineer approved equal

2.02 MANUFACTURED UNITS

A. Provide roof mounted units complete with electric heating elements and electric refrigeration as scheduled.

B. Provide units which are self-contained, packaged, factory assembled and prewired consisting of insulated cabinet and frame, supply fan, electric heating elements, controls, air filters, refrigerant cooling coil and compressor, condenser coil and condenser fan.

2.03 MATERIALS

A. Cabinet: Galvanized steel with baked enamel finish, access doors or removable access panels, with quick fasteners, screwdriver operated flush cam type or locking door handle type with piano hinges. Provide structural members a minimum of 18 gage with access doors or removable panels a minimum of 20 gage.

B. Insulation: 1 inch thick neoprene coated glass fiber on surfaces where conditioned air is handled. Protect edges from erosion.

C. Supply Fan: Forward curved centrifugal type, resiliently mounted with V-belt drive, adjustable variable pitch motor pulley and rubber isolated hinge mounted motor or direct drive. Isolate complete fan assembly.
D. Air Filters: 1-inch thick permanent washable.

E. Roof Mounting Frame: 14-inch high galvanized steel channel frame with gaskets and nailer strips.

2.04 EVAPORATOR COIL

A. Provide copper or aluminum tube and aluminum fin assembly with galvanized drain pan and connection.

B. Provide thermostatic expansion valves and alternate row circuiting for units 7-1/2 tons cooling capacity and larger.

2.05 COMPRESSOR

A. Provide the compressor which is hermetic or semi-hermetic, 3600 rotations per minute maximum, resiliently mounted with positive lubrication, crankcase heater, high and low pressure safety controls, motor overload protection, suction and discharge service valves and gage ports, and filter dryer.

B. Delay compressor start with five minute timed off circuit.

C. Provide outdoor thermostat which will energize compressor control circuit above 35 degrees F ambient.

D. For heat pump units, provide reversing valve, suction line accumulator, discharge muffler, flow control check valve and solid state defrost control utilizing thermistors.

E. Provide hot gas bypass or cycling compressors for capacity control.

2.06 CONDENSER

A. Provide coil with copper or aluminum tube and aluminum fin assembly with subcooling rows.

B. Provide condenser fans which are direct drive propeller fans, resiliently mounted with fan guard, motor overload protection wired to operate with compressor.

C. Provide heat pressure control by refrigerant pressure switches cycling the condenser fans for unit operation down to 35 degrees F outdoor temperature.

2.07 SUPPLY/RETURN CASING

A. Dampers: Provide outside, return and relief dampers with damper operator and control package to automatically vary outside air quantity.

B. Gaskets: Provide tight fitting dampers with edge gasket, maximum leakage 5 percent at 2 inches WC pressure differential.

C. Damper Operator: Provide 24 volt with gear train sealed in oil with spring return on units 7-1/2 tons cooling capacity and larger.
2.08 OPERATING CONTROLS - SINGLE ZONE UNITS

A. Electric solid date microcomputer based room thermostat located as indicated in service area with remote sensor located as indicated.

B. Incorporate the following in room thermostat:

1. Automatic switching from heating to cooling
2. Preferential rate control to minimize overshoot and deviation from set point
3. Set-up for four separate temperatures per day
4. Instant override of set point for continuous or timed period from one hour to 31 days
5. Short cycle protection
6. Programming based on weekdays, Saturday and Sunday
7. Switch selection features including imperial or metric display, 12 or 24-hour clock, keyboard disable, remote sensor, fan ON-AUTO switch

C. Include room thermostat display as follows:

1. Time of day
2. Actual room temperature
3. Programmed temperature
4. Programmed time
5. Duration of timed override
6. Day of work
7. System model indication: heating, cooling, auto, off, fan auto and fan on
8. Stage (heating or cooling) operation

2.09 PERFORMANCE

A. Base performance on ARI 210/240 test conditions unless specified otherwise. Sound rating numbers are in accordance with ARI 270.

B. Rated heating and cooling capacities shall be as scheduled on the Contract Drawings.
PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that roof is ready to receive work and opening dimensions are as indicated on shop drawings.

B. Verify that proper power supply is available.

3.02 INSTALLATION

A. Install in accordance with manufacturer's instructions and NFPA 90A.

B. Mount units on factory built roof mounting frame providing watertight enclosure to protect ductwork and utility services. Install roof mounting frame level.

3.03 FIELD QUALITY CONTROL

A. Manufacturer's Field Services: Provide initial startup and shutdown during first year of operation including routine servicing and checkout.

END OF SECTION
SECTION 16000
BASIC ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.01 DESCRIPTION
A. Section includes specifications for furnishing and installation of all electrical systems, including the checkout and startup of the systems.

1.02 GENERAL
A. Provisions specified in this Section apply to all Division 16, Electrical.
B. The types of systems covered by this Section include AC normal and emergency power supply equipment; railroad signals, train control, and communications; station lighting, communications, and amenities; fire alarm systems; and power supply to HVAC systems. Systems include electrically driven motors and pumps.
C. The general extent of the electrical work includes furnishing and installing the following items:
   1. Raceways, conduit, junction boxes, wire, cable and connectors required to inter-connect and place all equipment in complete operation.
   2. Power distribution systems, overcurrent protection, load transfer switches, electrical panels and switchboards, fused and unfused disconnects, receptacle outlets, switching, and circuits as indicated on the Contract Drawings.
   3. Complete grounding systems.
   4. Site electrical service conduits, equipment pads, manholes, handholes, splice boxes, excavation, trenching, backfill, and compaction.
   5. Lighting including fixtures, lighting poles, outlets, switching, and circuits.

1.03 REFERENCE STANDARDS
A. Institute of Electrical and Electronics Engineers (IEEE):
   1. 81 Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

1.04 DESIGN REQUIREMENTS
A. Design anchorage and secure electrical equipment in accordance with applicable code. In addition, design anchorage and secure equipment to withstand a lateral force of 0.6 times the weight of the equipment, if such requirement is more stringent.
B. Size conduits, raceways, and junction boxes with minimum 20 percent spare or expansion capacity.

C. Locate electrical equipment in a manner suited to the application and install per the original equipment manufacturers’ (OEM) recommendations and applicable code.

D. Provide circuit schedule for all lighting and power panel boards.

E. Unless designed or rated for exterior use or provided with its own housing or enclosure, install electrical equipment in a manner such that it is adequately protected from the local environment (such as rain and dust). Provide temperature controls (ventilating fans or air conditioning) in the enclosed space if the temperature will exceed the OEM recommended operating temperatures.

1.05 SUBMITTALS

A. Material List: Submit list of materials and equipment proposed for use in the work. Except as specified herein for "rough-in" materials, submit complete list at one time and include all proposed alternatives.

1. Include name of manufacturer and where applicable, brand name, type and/or catalog number of each item. Do not list more than one manufacturer for any one item of equipment. Do not list items "as specified", without both make and model or type designation.

2. "Rough-in" materials, such as conduit, fittings, junction boxes, 600V power conductors, and outlets, need not be included in the Material List, provided that these items are as specified and are listed by UL.

B. Shop Drawings and Descriptive Data: As soon as practical after submission of Material List, submit shop drawings and descriptive data of equipment listed hereinafter, and the required wiring diagrams. Include copies of catalog cuts including complete description, information, and performance data.

C. Panelboard Directories: Submit for approval.

D. Calculations: Submit structural calculations showing that equipment anchorage will withstand applicable lateral force. Submit other calculations as specified in individual Sections. Calculations shall be signed and sealed by professional engineer licensed in the State of California.

E. Manufacturer Seismic Qualification Certification: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces according to applicable code and other Contract requirements, whichever is most stringent. Include the following:

1. Basis of Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. The term “withstand” means the unit will remain in place without separation of internal and external parts during a seismic event and the unit will be fully operational after the event.

3. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

4. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

F. Qualifications: Submit evidence of qualifications of electrical field engineer.

G. Test Procedures: Submit test procedures for testing electrical equipment installation and operation.

H. Test Reports: Submit test reports within 30 days of completion of test.

1.06 PROJECT RECORD DOCUMENTS

A. Refer to Section 01720, Contract Record Documents, for general requirements. Mark Project Record Documents daily to indicate all changes made in the field.

1. In addition, indicate on Contract Drawings any changes on equipment locations and ratings, trip sizes and settings on magnetic-only circuit breakers, alterations in raceway runs and sizes, changes in wire sizes, circuit designations, installation details, one-line diagrams, control diagrams and schedules.

2. Accurately record on Contract Drawings the actual locations and exact routing of duct bank. Locate underground conduit stubbed-out for future use, underground feeder conduits, and feeder pull box locations using building lines.

3. Show pull box number, conduit layout with number of bends, total number of cables and wires in each conduit, and indicate spare or empty conduits.

4. Use same symbols as used on Contract Drawings.

1.07 REGULATORY REQUIREMENTS

A. Comply with the following codes and regulatory requirements:

1. California Code of Regulations (CCR)

2. California Public Utilities Commission (CPUC) General Orders and Regulations

3. Institute of Electrical and Electronics Engineers (IEEE):

   IEEE C2 National Electrical Safety Code

   NFPA 70       National Electrical Code (NEC)

1.08 QUALITY ASSURANCE

A. Field Engineer: Provide a qualified field engineer with a minimum of 10 years of experience in the installation of electrical equipment and systems. The Field Engineer shall perform the following:

1. Prepare detailed Shop Drawings. Review submittals prior to submitting to the Engineer.

2. Inspect equipment for compliance with specified requirements and accepted Shop Drawings at worksite.

3. Prepare field inquiries and work to resolve identified field issues related to installation of electrical equipment and systems.

4. Prepare and coordinate approval with the Engineer any recommended field modifications to controls and equipment received at Worksite.

5. Oversee and monitor electrical work installation, and design and installations of temporary electrical systems in accordance with NFPA 70.

6. Perform or witness specified field tests.


8. Witness vendor equipment performance tests and inspection.

9. Identify and track work non-conformances and assist with corrective action to remove non-conforming work.

B Equipment shall be standard products of manufacturers regularly engaged in the production of such equipment and material. In addition to the requirements for an “equal” specified under the General Provisions, for a standard product to be considered an equal to equipment specified, such products shall have been proven in commercial service for a period of at least two years.

1.09 COORDINATION WITH OTHER WORK AND UTILITIES

A. Review civil, architectural, and structural Contract Documents. Plan work to conform to conditions shown and specified to provide the best assembly of the combined work.

B. Work out "tight" conditions in advance.

C. Where the work of several trades is involved, coordinate all related work to provide each system in complete and proper operating order.
D. Coordinate electrical service with utility company, including design and installation of load transfer equipment. Verify with the utility company the available fault current at the incoming service connection point and provide appropriately rated service equipment and overcurrent protection devices.

E. Verify with the phone company their requirements and identify interface points prior to start of work.

PART 2 - PRODUCTS

2.01 NAMEPLATES

A. Equipment Labels and Nameplates:

1. Construction: Laminated phenolic plastic, black front and back, white core, with lettering etched through outer covering. Use 3/16 inch high lettering at push button stations, thermal overload switches, receptacles, wall switches, and similar devices, where nameplate is attached to device plate. Use 1/4 inch high lettering at all other locations, unless otherwise specified or detailed. Engraving directly on device plates with black enamel filled lettering is acceptable in lieu of separate plastic nameplates. Motor nameplates may be of nonferrous metal, 0.03-inch thick minimum, die stamped.

2. Inscription: If detailed on the Contract Drawings, use inscription exactly as shown; otherwise, describe adequately function or use of equipment involved.

   a. For Panelboards and Switchboards: Include panel designation, voltage and phase of supply, e.g., "Panel A, 480/277 V, 3 ph."

3. Provide nameplates on the following equipment:

   a. Metered service pedestal, meter/main service boxes, service switchboards, panelboards, push button stations, control panels, time switches, disconnect switches, thermal overload switches.

   b. Circuit breakers, contactors, or relays in separate enclosures.


B. Circuit Panelboard Directories: Create directory after balancing panel board loads. Provide neatly typed schedule (odd numbered circuits on left side, even on right side) under plastic jacket or protective cover to protect the schedule from damage or dirt. Securely mount on inside face of panelboard door. Briefly and accurately define nature of connected load. Do not use sequentially numbered schedules.

C. One-Line Diagram: Provide approved "one line" for the "As-Built" distribution system.
D. Empty Conduits: Provide tags with typed description of purpose and location of opposite end, wired to each end of conduits.

PART 3 - EXECUTION

3.01 GENERAL

A. Fasten nameplates securely to equipment.

B. Provide pull rope in all conduits, including spare conduits.

3.02 VOLTAGE CHECK

A. At completion of job, check voltage at several points of utilization on the system that has been installed under this Contract. During test, energize all loads installed.

B. Set taps on transformers to give proper voltage, which is 118 to 122 volts for 120-volt nominal systems and proportionately equivalent for higher voltage systems.

C. If proper voltage cannot be obtained, inform the Engineer.

3.03 FIELD QUALITY CONTROL

A. Perform tests, in accordance with approved procedures, to prove installation is in accordance with contract requirements. Perform tests in presence of the Engineer, and furnish test equipment, facilities, and technical personnel.

B. Request for Tests: Notify the Engineer a minimum of 24 hours in advance of tests. In the event the Engineer does not witness the test, certify in writing that all specified tests have been made in accordance with the specifications.

C. Deficiencies: Immediately correct deficiencies, which are evidenced during the tests and repeat tests until system is approved. Do not cover or conceal electrical installations until satisfactory tests are made and approved.

D. Tests:

1. Test panel and circuits for grounds and shorts with mains disconnected from feeder, branch circuits connected, circuit breakers closed, all fixtures in place and permanently connected, without lamps, and all switches closed.

2. Test each individual circuit at the panel with equipment connected for proper operation.

3. Ground tests:
   a. Ground tests shall meet requirements of CCR, Title 24.
b. Perform fall-of-potential test or alternative in accord with IEEE 81 on the main ground electrode or system.

c. Perform point-to-point tests to determine resistance between main ground system and all major electrical equipment frames, system neutral, and/or derived neutral points.

d. Test Values: Resistance between main ground electrode and ground shall be no greater than 25 ohms. Additional rods shall be installed and bonded to grounding system and driven to a depth of 50 ft. or refusal, whichever comes first. Investigate point-to-point resistance values that exceed 0.5 ohm.

e. Record all test values and submit certified copies to the Engineer.

4. Cables:

a. Make insulation resistance tests on all power cables, using a self-contained instrument such as the direct-indicating ohmmeter of the generator type, or “megger” such as manufactured by J.G. Biddle Company or equal. Insulation resistance values shall be at least 75 percent of shop test records.

b. Apply the following test voltages for one (1) minute, except where specified otherwise herein, in accord with procedure recommended by manufacturer of test equipment and as specified herein.

<table>
<thead>
<tr>
<th>Rated Circuit Voltage</th>
<th>Megger Voltage (DC)</th>
<th>Min. Megger Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>600 Volts</td>
<td>500 Volts</td>
<td>600 Kilo-ohms</td>
</tr>
</tbody>
</table>

c. Record all test values and submit certified copies to the Engineer.

d. Replace cables not meeting specified resistance values.

3.04 CLEANING

A. After other work such as sanding, painting, and similar work has been completed, clean lighting fixtures, panelboards, switchboards, and other electrical equipment to remove dust, dirt, grease, or other marks, and leave work in clean condition.

END OF SECTION
SECTION 16060
GROUNDING AND BONDING

PART 1 – GENERAL

1.01 DESCRIPTION
A. Section includes requirements for an electrical grounding system, including electrodes, grounding rods, connectors, insulators, equipment grounding and bonding conductors, and wire and cable grounding conductors and joints.

1.02 REFERENCE STANDARDS
A. American National Standards Institute (ANSI):
   1. J-STD-607 A Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications.
B. American Society of Testing and Materials (ASTM International):
   1. B3 Standard Specification for Soft or Annealed Copper Wire
   2. B187 Standard Specification for Copper, Bus Bar, Rod, and Shapes and General Purpose Rod, Bar, and Shapes
C. California Code of Regulations (CCR):
   1. Title 24, Part 3, California Electrical Code
D. National Fire Protection Association (NFPA):
   1. NFPA 70 National Electrical Code (NEC)
E. Underwriters Laboratories Inc. (UL):
   1. UL 467 Grounding and Bonding Equipment

1.03 SUBMITTALS
A. Refer to Section 16000, Basic Electrical Requirements, for additional submittals and submittal requirements.
B. Submit shop drawings showing locations of ground rods, grounding connections, and embedded and buried grounding conductors.
C. Submit product data including manufacturer’s catalog cuts showing all specified items.
D. Submit test procedures. Include description of method of measuring grounding resistance. Include plan showing locations of test points to measure grounding resistance items.
E. Submit report of test results of grounding resistance.

PART 2 – PRODUCTS

2.01 GROUNDING AND BONDING EQUIPMENT

A. Equipment: Conform to UL 467, with additional requirements as specified herein.

2.02 GROUNDING CONDUCTORS

A. Grounding conductors shall comply with NEC Articles 250.118, 250.119 and 250.122.

2.03 GROUND RODS

A. Material: ASTM B187, medium carbon steel core, copper-clad by the molten weld casting process.
B. Size: 3/4 inch diameter; 10 feet long

2.04 MECHANICAL CONNECTORS

A. Material: Bronze

2.05 COMPRESSION CONNECTORS

A. Material: High conductivity electrolytic copper tubing, heavy wall
B. Manufacturer: Burndy Electrical, Thomas & Betts, or Engineer approved equal

2.06 EXOTHERMIC CONNECTIONS

A. Manufacturer: Cadweld, Division of Erico, or Engineer approved equal.

2.07 WIRE

A. Material: ASTM B3, bare soft drawn stranded copper
B. Grounding Electrode Conductor: Size to meet NFPA 70 requirements and the requirements of Section 16100, Wiring Methods.
C. Insulated general wiring: Type THHN/THWN for grounds routed in conduit with feeders. Size as noted on the Contract Drawings. Insulation: Green in color or taped ends as allowed by code.

2.08 BARE CONDUCTORS

A. Bare Conductors: ASTM B3, Class B stranded annealed copper conductor unless otherwise indicated.
B. Bare Copper Cables for Direct Burial in Earth: No smaller than No. 2 AWG, having stranding no smaller than No. 12 AWG.
C. Bare Copper Cables for Use for Concrete Encased Grounds: No smaller than No. 2 AWG, having stranding no smaller than No. 14 AWG.

D. Flexible copper braid, minimum cross-sectional area 24,000 cir. Mils (No. 6 AWG), minimum strand size No. 30 AWG.

E. Copper ground bus assembly, minimum 1/4 inch x 3 inches x 12 inches drilled and tapped every 2 inches on center for two-hole lugs.

F. Bus bar insulators shall be fibrous glass reinforced polyester.

G. Terminals, two-hole lug, compression type.

H. Counterpoised Grounding Electrode Conductor: #4/0 AWG bare soft drawn stranded copper.

2.09 JUMPERS

A. Tin-plated copper, braided, flexible jumper.

2.10 SINGLE CONDUCTOR INSULATED WIRE

A. As specified in Section 16100, Wiring Methods.

PART 3 – EXECUTION

3.01 GENERAL REQUIREMENTS

A. Install products as indicated on the Contract Drawings.

B. Provide grounding and bonding to meet NEC and ANSI/J-STD-607 A requirements.

C. Use continuous ground conductor without splices.

D. Install counterpoised grounding electrode system for OCS (Overhead Catenary System) system and bond to platform reinforcement as indicated on the Contract Drawings.

3.02 GROUND CONNECTIONS

A. Provide separate, insulated conductor within each feeder and branch circuit raceway. Terminate each end on suitable lug, bus, or bushing.

B. For above ground connections, install compression type terminal lugs or mechanical bolted connectors.

C. Exothermic weld buried and embedded ground connections: Make welds in accordance with manufacturer’s requirements.

D. Make connections to ground bus assembly in the following manner:
1. Bond cable to two-hole lug using exothermic welding process
2. Bolt two-hole lug to ground bus assembly

3.03 GROUND RODS

A. Install rod electrodes for electrical service panel and in handholes as indicated. Install and tie-in additional rods as required to achieve the resistance to ground specified under “Field Quality Control” in this Section.

B. Verify that final grading has been completed before driving rod electrodes. Coordinate with the work performed under Section 02300, Earthwork.

C. Bury ground rods vertically with rod top a minimum two feet below grade or with rod top exposed a minimum of 3 inches in handholes. Use ground rod for main grounding system. If extensive rock formation is encountered, relocate ground rods as approved by the Engineer.

3.04 SERVICE EQUIPMENT

A. Ground neutral bus to ground bus and ground bus to ground rod.

B. Run insulated ground conductor in conduit with all feeder and branch circuits.

3.05 EQUIPMENT GROUNDING

A. Ground stationary equipment enclosures as required by the applicable codes.

B. Ground metallic conduits, raceways, boxes, cabinets, cable trays, panelboards, disconnect switches, exposed expansion joints, receptacles, and lighting fixtures in accordance with NEC.

C. Ground outdoor light poles as indicated on the Contract Drawings.

D. Ground frames of motors by ground conductor carried in power conduit. Provide ground conductor sized in accordance with NEC.

E. Bond all conduits that are used for parallel feeders.

F. Feeders: Install ground conductor for the feeder rating in each conduit.

G. All metallic structures, including station shelters, station lighting poles, metallic equipment cabinets, metal benches, railings, metal fences, and other metallic structures within a 10 ft distance to the centerline of an OCS line or supporting structure, shall be bonded to the OCS system counterpoise ground with a #2 AWG bare copper wire.

3.06 FIELD QUALITY CONTROL

A. Refer to Section 16000, Basic Electrical Requirements, for basic test procedures, as augmented by test procedures submitted under this Section.
B. Perform tests in accordance with approved test procedures in coordination with the Field Engineer.

C. In the presence of the Engineer, test the grounding system by the fall-of-potential method to demonstrate that total ground resistance does not exceed the value specified in the Contract Documents. If necessary, install additional ground rods to meet this resistance requirement.

D. Test equipment enclosures, conduit, raceways and lighting fixtures for continuity to the ground system.

E. Test counterpoise grounding electrode system resistance to remote ground using the 3-point fall of potential method. Counterpoise grounding electrode resistance shall not exceed 5 ohms.

END OF SECTION
SECTION 16100
WIRING METHODS

PART 1 - GENERAL

1.01 DESCRIPTION
A. Section includes requirements for wire and cable of 600 volts or less.

1.02 REFERENCE STANDARDS
A. California Code of Regulations (CCR):
   1. Title 24, Part 3, California Electrical Code
B. National Fire Protection Association (NFPA):
   1. NFPA 70 National Electrical Code (NEC)
C. Underwriters Laboratories Inc. (UL):
   1. UL 83 Thermoplastic-Insulated Wires and Cables
   2. UL 969 Marking and Labeling Systems
   3. UL 1569 Metal-Clad Cables
   4. UL 1581 Reference Standard for Electrical Wire, Cable and Flexible Cord

1.03 SUBMITTALS
A. Refer to Section 16000, Basic Electrical Requirements, for additional submittals and submittal requirements.
B. Submit manufacturer’s product data for wires and cables, wire connectors, insulating tape, wire markers, and miscellaneous wiring materials.
C. Submit test procedures for verification of circuit operation.
D. Submit results of tests and verification of testing of all electrical systems and circuits.

PART 2 – PRODUCTS

2.01 LABELING AND MARKERS
A. Conductors shall be delivered to the job site plainly marked on 24-inch centers. Markings on cables shall be white lettering with black jacketing for conductor sizes of No. 6 and larger. Indentations for lettering are not acceptable. Markings shall be as follows:
1. Per UL 969
2. Gauge
3. Voltage
4. Kind of Insulation
5. Name of Manufacturer
6. Trade Name

B. Conductor labels shall be with PVC tubing with machine printed black marking. Tubing shall be sized to fit conductor insulation. Adhesive strips are not acceptable.

C. Power and Control Conductors Markers or Labels: Plastic-coated, self sticking markers such as Thomas & Betts E-Z Code or Brady "Perma Code", or field-marked labels such as manufactured by Panduit. Label shall be permanent and non-handwritten.

2.02 CONDUCTORS

A. Conductors shall be sized according to American Wire Gauge (AWG). Stranding, insulation, rating, and geometrical dimensions shall conform to UL Specifications and bear the label of a nationally recognized testing laboratory.

B. Wire and cable for secondary power, lighting and control circuits shall be rated for 600 V. Use wire with following types of insulation at the specified locations:

1. Dry Locations: Type THHN/THWN or XHHW
2. Wet locations: Type XHHW-2
3. Branch Circuits within 3 inches of Fluorescent Lamp Ballasts: Type XHHW or Type THHN (Applies to fixtures where circuit wiring is in same compartment with ballasts).
4. Minimum 75 degrees C temperature rated insulation on conductors, except minimum 90 degrees C temperature rated insulation on conductors in conduits exposed on roof or wet locations.
5. Conductors for general wiring: Thermoplastic insulation rated for 600V manufactured in accordance with UL 83. Copper conductors, 3/4 hard drawn. Cable sizes No. 8 AWG or larger shall be stranded conductors.
6. At Motors and Other Applications Where Subject to Vibration: Stranded conductors.
2.03 600 VOLT METAL CLAD CABLE (MC)

A. Lightweight, interlocked steel galvanized armor sheath applied over the cable core in accordance with UL 1569 and NEC Article 330.

B. Cable shall have the required number of conductors and shall include a separate, internal ground conductor, no smaller than indicated on the Drawings. Ground conductor shall meet NEC requirements for equipment grounding conductor.

C. MC cable assembly shall be rated for 90 Degrees Celsius in wet and dry locations.

D. Color coding for conductors shall be as specified in paragraph 3.01 below.

2.04 600 VOLT SERVICE DROP CABLE

A. Service drop cable shall be triplexed, aluminum conductor, 600 volt rated, with 75 Degrees Celsius polyethylene insulation. Messenger wire shall be all aluminum conductor (AAC). Conductor sizes shall be as indicated on the Contract Drawings.

2.05 PULLING LUBRICANT

A. Wire pulling lubricant shall be a wire pulling compound approved by a nationally recognized testing laboratory.

1. Aqua Gel II, as manufactured by Ideal Industries, Sycamore, IL, or Engineer approved equal.

2.06 WIRING MATERIALS

A. Connectors for Copper Conductors No. 10 AWG and Smaller:

1. Pre-insulated Spring Pressure Type: Scotchlok Types Y, R, G and B; Ideal "Wing Nut"; T & B Series PT, or equal.

2. Splice Cap Type: Un-insulated metal cap applied with proper indenter tool which provides deformation of cap in 2 directions at right angles to each other, Buchanan, or Engineer approved equal.

B. Connectors for Fixture Leads: Pre-insulated spring pressure type as specified above for conductors; or set screw type, Marr, Ideal, or Engineer approved equal.

C. Connectors and Lugs for Copper Conductors No. 8 AWG and Larger: Compression type, Burndy, Dossert, T & B, or Engineer approved equal.

D. Watertight Splice Kits: Epoxy resin type, suitable for the type, size and number of conductors being spliced.

E. Splicing and Insulating Electrical Tape (600 V and Below): General purpose electrical tape shall be suitable for temperatures from 18 deg C to 105 deg C and...
shall be black, ultraviolet proof, self extinguishing, 7 mil thick vinyl.

F. Washers:

1. Flat washer: Mild steel, tin plated, and slightly larger than Belleville washer.

2. Belleville washer: Either hardened or tempered steel or stainless steel.

PART 3 – EXECUTION

3.01 WIRING METHODS

A. General Requirements:

1. Use No. 12 AWG or larger wire for light and power circuits and No. 14 AWG or larger wire for control circuits, unless smaller wire is specified or shown.

2. Unless otherwise specified or shown, leave at least 9 inches of free conductors at each unconnected outlet. Tape free ends of conductors and coil neatly in outlet box.

3. All cable conductors of 3-phase circuits of single-phase shall be of the same type. Mixing stranded conductors for some phases with others as solid is not acceptable.

B. Splicing and Termination of Conductors:

1. Conductors No. 10 AWG and Smaller:

   a. Twist conductors together to be electrically and mechanically secure by means of pre-insulated spring pressure connectors or un-insulated splice caps applied with proper indenter tool designed for the specific type of cap used. Twist conductors together before applying splice caps.

   b. Insulate splices, joints and free ends of conductors with insulation equivalent to that of conductors by taping with rubber and friction tapes, or with high dielectric strength plastic tape.

   c. If splice caps are used, plastic insulating caps may be used. After applying splice caps, use insulating caps rated for the temperatures to which they may be subjected, and install as recommended by the manufacturer.

2. Conductors No. 8 AWG and Larger:

   a. Splice and terminate conductors by means of compression connectors and compression terminal lugs.

   b. Do not use split bolt type connectors.
c. After initial set has been taken, retighten all pressure type connectors and lugs.

d. Insulate all splices, joints, and free ends of conductors as specified on this Section.

e. Where aluminum lug is bolted with steel or copper bolt, use Belleville spring washer and flat washer.

3. Underground Splices: Conductor and cable splices installed underground in manholes, pull boxes and similar locations, shall be made watertight. Splices for lead-sheathed cables shall be wiped lead joints. Approved splice kits may be used for conductors and cables other than lead-sheathed.

C. Color Coding:

1. Color code for general wiring as follows:

   a. For 240/120V, 1-phase system:
      Phase A: Black
      Phase B: Red
      Neutral: White

   b. For 240/120V and 208/120V, 3-phase system:
      Phase A: Black
      Phase B: Red
      Phase C: Blue
      Neutral: White

   c. For 480/277V, 3-phase system:
      Phase A: Brown
      Phase B: Orange
      Phase C: Yellow
      Neutral: Gray

   d. Ground conductors:
      i. Bare copper conductor may be used for equipment ground only.

      ii. Insulated ground conductors:
          Ground conductor: Green
          Isolated ground conductor: Green with white stripe

2. Use green color for any conductor intended solely for equipment grounding, unless it is bare.

3. Use wire with insulation of required color. For other types of wire, which may not be available in specified colors, use self-adhesive wrap-around cloth type markers of solid colors to color code conductors.
4. Where wire markers are used for color coding, mark each conductor at all accessible locations (panelboards, junction boxes, handholes, auxiliary gutters, outlets, switches, control centers and similar devices).

D. Conductor Identification:

1. Feeders: Identify with the corresponding circuit designation at overcurrent device and load ends, at all splices, and in pull boxes.

2. Branch circuits: Identify with corresponding circuit designation at overcurrent device and at all splices.

3. If more than one white (neutral) conductor is present, mark each with all related circuit numbers.

4. Control Wires: Identify with indicated number and or letter designation at all terminal points and connections, including manufacturer pre-wired control sections and cabinets.

5. Alarm and Detection Wires: Identify with indicated wire and mnemonics numbers at all connections, terminal points, and coiled conductors within cabinets.

6. Identify power and control conductors using markers or field-marked labels.

3.02 INSTALLATION

A. Use approved specified wire pulling lubricant. Do not use oil, grease, or similar indiscriminate substances to facilitate the pulling in of conductors.

B. Pull wire into conduits with care and prevent damage to insulation. Use basket pulling grips to avoid slipping of insulation on conductors.

C. Do not use blocks, tackle, or other mechanical means to pull wires No. 8 AWG, or smaller.

D. When pulling conductors, do not exceed manufacturer’s recommended pull tension values.

E. Dress harness all wire and cable to prevent mechanical stress on electrical connections. No wire and cable shall be supported by a connection point.

F. Correct the following conditions: Deformed, brittle, or cracked insulation; insulation shrunk or stripped further than 1/8 inches away from the actual point of connection; cold solder joints, flux joints, and solder splatter; ungrommeted, unattached or uninsulated wire or cable entries; and deformation of improper radiusing of wire or cable, especially coaxial cable.

G. Install cable with a bend radius not less than that recommended by cable manufacturer. Provide a box loop for all wire and cable routed through junction boxes or distribution panels.
H. Remove debris and moisture from raceways, boxes, and cabinets before installing wire or cable.

I. Install MC cable at locations indicated on the Contract Drawings or at other locations approved by the Engineer.

J. Service drop cable shall be used only for temporary lighting installation and at other temporary installations as approved by the Engineer.

3.03 FIELD QUALITY CONTROL

A. Prior to operating test, the Field Engineer shall verify that all wiring and connections are done, all circuits are active and working properly, motor phases are wired properly, electrical switches are in the right direction, and that overall the system is ready for application of power and testing.

B. Operating Test: After installation has been completed, conduct an operating test. Demonstrate that equipment operates in accordance with the requirements of this Section. Furnish necessary instruments and personnel required for test.

END OF SECTION
SECTION 16130
CONDUIT AND FITTINGS

PART 1 – GENERAL

1.01 DESCRIPTION
A. Section includes requirements for conduit and conduit fittings. Conduit types shall be as shown on the Contract Drawings and as specified herein.

1.02 REFERENCE STANDARDS
A. American National Standards Institute (ANSI):
   1. C80.1 Electrical Rigid Steel Conduit (ERCS)
B. ASTM International (ASTM):
   1. A153 Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
C. American Welding Society (AWS):
   1. D1.1 Structural Welding Code - Steel
D. California Code of Regulations (CCR):
   1. Title 24, Part 3, California Electrical Code
E. Institute of Electrical and Electronics Engineers (IEEE):
F. National Electrical Manufacturers Association (NEMA):
   1. TC2 Electrical Polyvinyl Chloride (PVC) Conduit
   2. TC3 Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing
G. National Fire Protection Association (NFPA):
   1. NFPA 70 National Electrical Code (NEC)
H. Underwriters Laboratories Inc. (UL):
   1. UL 6 Electrical Rigid Metal Conduit - Steel
2. UL 651 Schedule 40 and 80 Rigid PVC Conduit and Fittings

1.03 DESIGN REQUIREMENTS

A. In addition to requirements specified in Section 16000, Basic Electrical Requirements, design supports to support the following loads.

1. Support load equal to sum of weights of conduits and wires, and weight of hanger plus 200 pounds.

2. Stress at root of thread of hanger rods: Not more than 9475 psi at design load.

3. Size horizontal member to limit maximum stress of not more than 12,650 psi at design load.

1.04 SUBMITTALS

A. Refer to Section 16000, Basic Electrical Requirements, for additional submittals and submittal requirements.

B. Submit manufacturer’s product data for all types of conduit and fittings to be used.

C. Shop drawing information may be combined on a single drawing. Identify each drawing by a number and descriptive title.

D. Submit records of grout quantity installed in casings.

E. Submit test reports.

1.05 DELIVERY, STORAGE AND HANDLING

A. Install thread protectors both ends of galvanized rigid steel conduits for shipment and handling.

B. Package couplings separately.

PART 2 - PRODUCTS

2.01 GENERAL

A. Conduit and conduit fittings shall be standard types and sizes as manufactured by a nationally recognized manufacturer of this type of materials, and be in conformity with standards.

2.02 RIGID GALVANIZED STEEL CONDUIT (RGS)

A. Provide conduit, couplings, elbows, bends, sealing fittings, and nipples conforming to ANSI C80.1 and UL 6, with each length bearing manufacturer’s stamp and UL label.

B. Couplings, locknuts, and all other fittings shall be galvanized, waterproof, and threaded type only.
C. Bushings shall be nylon insulated metallic and grounding type.

D. Furnish conduit straps, clamps and clamp backs made of galvanized malleable iron.

2.03 POLYVINYLCHLORIDE (PVC) CONDUIT

A. Schedule 40 and schedule 80 rigid polyvinyl chloride electrical conduit conforming to the requirements of EPC-40-PVC and EPC-80-PVC conduit of NEMA TC 2 and fittings for EPC-40-PVC and EPC-80-PVC conduit of NEMA TC 3 and listed by UL for direct underground burial, manufactured from high impact, non-conducting, self-extinguishing material.

B. Couplings, Adapters, Expansion Fittings: Conform to same requirements as rigid PVC conduit. Use solvent cement for PVC joints, as recommended by conduit manufacturer.

C. Bends: Factory made PVC bends.

D. PVC conduits shall be Schedule 40 throughout the Work, except at rail crossing, which shall be PVC Schedule 80.

E. UL 651 listed and in accordance with NEC Article 352 for underground use.

F. Solvent for welding PVC shall comply with ASTM D 2564 or approved equal.

G. Minimum 10 foot assembled from factory section, 25 foot assembled from factory section preferred.

2.04 PULL CORD

A. Pull Cord or Rope: Twisted or braided nylon cordage, 1/4 inch diameter, with a minimum tensile strength of 1000 pounds. Pull cord shall be combination footage measuring tape and pull line.

2.05 MANDRELS

A. High-strength aluminum alloy with steel center rod and cast iron eyes.

B. Use solid cylindrical type mandrels, minimum 12 inches long and 1/4 inch less than diameter of duct at center, tapering to 1/2 inch less than duct size at ends.

2.06 CONDUIT SUPPORTS

A. Steel shapes, angles and channels: 1 1/2 by 1 1/2 or 1 5/8 by 1 5/8 inches, 12 gauge, cold-formed, lipped channel; designed to accept special spring-held hardened steel nuts for securing hanger rods and other attachments.

B. Single Conduit Hangers: Steel City No. C-149, Unistrut No. J1205 through J1260, or Engineer approved equal, with 3/8 inch minimum diameter steel rod.
C. Riser Supports: Steel City No. C-210, or Engineer approved equal.

2.07 REINFORCED PLASTIC MORTAR SPACERS (RPM)

A. Duct Spacers: Refer to Section 02500, Underground Ductwork and Structures.
B. Bore spacers shall be made from high density polyethylene (not less than 0.96 specific gravity), as manufactured by Formex Manufacturing, Inc., Underground Devices Inc. make, or Engineer approved equal.
C. Steel Bands and Polypropylene Straps for Securing Ducts in Bore Spacers: Provide means of securing conduits to bore spacers in accordance the bore spacers manufacturer’s written instructions. At minimum provide one of the following means:
   1. 5/8 inch by 0.30 inch galvanized steel bands and buckles having a minimum breaking strength of 1405 lbs.
   2. 3/4 inch wide polypropylene strapping having a 1400 lb breaking strength, 7 percent maximum stretch, and steel seals.

2.08 UTILITY MARKER TAPE

A. Tracer Tape: As specified in Section 02300, Earthwork. Use in trenches containing electric and power circuit. Tape shall have printed warning that an electric circuit is located below the tape.

2.09 CONDUIT EXPANSION FITTINGS

A. Fabricate from material similar to type conduit with which used.
B. Include factory installed packing ring and pressure ring; prevent entrance of moisture.
C. Include grounding ring or grounding strap for metallic expansion couplings.

2.10 INSERTS

A. Channel Inserts:
   1. Fabricate from cold-formed steel channels 12 gauge or thicker; overall size 1 1/2 inches by 1 1/2 inches or 1 5/8 inches by 1 5/8 inches; lengths as indicated. Hot-dip galvanize after fabrication in accordance with ASTM A153.
   2. For Embedding in Concrete:
      a. Fabricate from channels having a solid base
      b. Weld concrete anchors to channel during fabrication and before coating
      c. Clean and galvanize after fabrication
d. Provide assemblies with minimum pull-out load rating of 4500 pounds per linear foot uniformly distributed.

e. Furnish channel inserts for embedded installation in concrete with channel interior completely filled with Styrofoam.

3. For Surface Mounting:
   a. Fabricate from channel with 3/8 inch by 3 inches slots on 4 inches centers in base.
   b. Galvanize inserts for surface mounting on concrete surfaces, and for installation in damp or wet areas in accordance with ASTM A153.
   c. Use galvanized expansion shield type anchor bolts.

B. Spot Inserts for Embedding in Concrete:
   1. Steel, galvanized after fabrication in accordance with ASTM A 153.
   2. Design for maximum loading of 800 pounds with safety factor of three.
   3. Knockout openings: Designed to accommodate square or rectangular nuts.

2.11 FILLING MATERIALS

A. Furnish fire-resistive filling material for openings similar to the material of the floor, wall or ceiling being penetrated, and finish to prevent passage of water, smoke and fumes.

B. Where conduits passing through openings are exposed in finished rooms, use filling material that matches the adjoining finished floor, ceiling, or wall.

2.12 END CAPS

A. Provide end caps at both ends of all empty conduits.

2.13 CASINGS

A. Casing to receive bore spacers and ducts shall be a minimum of 0.375 inch thick steel wall and shall be straight and true.

PART 3 – EXECUTION

3.01 GENERAL REQUIREMENTS

A. All exposed conduit, conduit embedded in concrete walls and embedded in concrete floor, and conduit from handhole to shelter equipment shall be threaded rigid galvanized steel, except as follows:
1. Rigid PVC conduit may be used:
   a. For direct earth burial outside of building foundations, only where specifically shown on Contract Drawings and if buried not less than 24 inches below the surface.
   b. PVC Schedule 80 conduit shall be used at rail crossings. Conduit shall be buried not less than 42” from the top of the rail tie.

B. For system higher than 150 volts to ground, maintain continuity of equipment ground across flexible conduit connection to motor outlet by installing bonding wire inside conduit and connecting each end of wire to outlet or junction boxes by separate bolt, or use liquid tight flexible conduit approved for this purpose.

C. For PVC conduits, maintain continuity of conduit system ground by installing copper grounding wire inside PVC conduit, per CCR, Title 24. Ground this wire at each accessible location (manhole, pullbox, cabinet, outlet and junction box, and similar locations) and at each termination.

D. Check embedded items for correct location and detail before concrete is placed.

E. Control erection tolerance requirements; do not impair strength, safety, serviceability, or appearance of installations. Determine exact locations of conduit.

F. Install trade size, type, and general routing and location of conduits, raceways, and boxes as indicated or specified.

G. When exposed or buried conduit passes through expansion or contraction joint in structure, install conduit at right angles to joint; provide approved conduit expansion fitting at joint.

H. Provide expansion fittings in conduit runs as required to compensate for thermal expansion.

I. Conduits exposed to different temperatures: Seal to prevent condensation and passage of air from one area to the other.

J. When field cutting of conduit is required, remove rough edges. Where conduit enters box or other fitting, provide bushing to protect wire from abrasion.

K. Provide a minimum slope of three inches to each 100 feet away from buildings and towards manholes or pull boxes; run in straight lines between indicated changes in direction.

L. Perform welding in accordance with AWS D1.1.

3.02 EXCAVATION, TRENCHING, AND BACKFILL

A. As specified in Section 02300, Earthwork, and as indicated in the Contract Documents.
3.03 REINFORCED PLASTIC MORTAR SPACERS (RPM)

A. Duct Spacers: Refer to Section 02500, Underground Ductwork and Structures.

B. Bore Spacers (For ducts installed inside casing):

1. Use one double wall bore spacer for every 5 feet of duct bank.

2. Construct a trough or feeder bridge at the leading end of the casing to support sections of duct bank as they are assembled and pulled into the casing.

3. Use “Off Center Weight Technique” or “Stabilization Cables” to prevent rotating of the duct bank (corkscrew) as it is pulled through the casing.

4. Hold bore spacers in place relative to the conduit to avoid excessive temporary thrust load on each bore spacer while grout is pump into the casing.

5. Hold duct bank in position at both ends to accommodate possible uneven thrust loads that may be generated during the grouting operation.

6. Do not exceed the hydraulic collapse pressure of the conduits during grouting operation.

7. Measure and record actual quantity of grout used.

8. Secure conduits to bore spacers by installing on each side of each bore steel bands and buckles or polypropylene strapping and steel seals.

3.04 UNDERGROUND CONDUITS

A. Refer to 02300, Earthwork, for provisions for trenching, backfilling, and tracer tape.

B. Verify conduit is continuous and not damaged by pulling mandrel through embedded conduit within five days after concrete placement.

C. Cap or plug ends of conduit with permanent cap or plug. Do not use duct tape to temporarily seal conduit. Prevent concrete and other materials from entering and obstructing conduit. Do not install bell end fittings on conduits in ungrounded pull boxes.

D. Sandpaper joints in PVC conduit; remove burrs, clean and dry joints, and brush with solvent cement recommended by manufacturer.

E. Heating or any other method shall not be used to produce a larger bend. A sweep radius shall never be less than 15 feet in any given section.

G. Install duct runs straight and true between pull boxes. Do not use bends except where shown on the Contract Drawings. For alignment curves, do not use more than 5 degree segments for each standard straight length.
H. Conduits smaller than three inches: Make horizontal and vertical changes in direction exceeding 10 degrees by long sweep bends; having minimum radius of 25 feet. Manufactured bends may be used at ends of short runs of 100 feet or less, but only at or within five feet of end of run. Sweep bends may be made up of curved or straight sections, or combinations. Manufactured bends: bend radius to centerline of all conduits not less than 10 times nominal diameter of conduit for ducts of three inches in diameter and larger.

I. Place underground raceways at minimum depth of 24 inches to top of sand encasement, or to top of conduit (as applicable), unless specifically indicated otherwise.

J. Plug all ends of unused ducts and conduits in pull boxes/manholes. Use plugs manufactured for the purpose.

K. Unless otherwise shown on the Contract Drawings, install an expansion joint with minimum range of 5 inches in every 100-foot length of PVC type conduit. Make all joints in PVC conduit with solvent cement, as recommended by conduit manufacturer.

L. During non-work hours, and at locations where installation of ducts is temporarily suspended or terminated, close ends of ducts with caps or plugs fitted to prevent entry of water or debris. Use caps or plugs designed for purpose by conduit manufacturer.

M. Inspect ducts and couplings to ensure only clean and undamaged units are incorporated in Work.

N. Refer to Article entitled Mandrel.

O. Provide flared bell ends on conduit and ducts entering manholes, handholes, and pull boxes.

P. Conduit runs shall have no more than three (3) 90 degree bends between pull boxes, between manholes, and from point to point from the last pullbox.

3.05 UNDERGROUND CONDUITS FOR COMMUNICATIONS

A. Conduit bends shall be in accordance with NEC and the California Electrical Code, with not more than 120 degrees in bend. Where more bends are required in a particular run, install pull boxes as required to facilitate pulling conductors. For straight conduit runs, maximum length without a pull box/manhole shall not exceed 500 feet. For conduit runs with some bends, maximum length without a pull box/manhole shall not exceed 400 feet.

B. Conduit stacks shall begin sweeps a minimum of 10 feet from exterior pull box face, leaving 10 feet of straight conduit perpendicular to cored entrance holes of pull box.
C. When conduit stack enter or exit in a straight line to a pull box face, conduit stack shall separate from common trench at a minimum distance of 30 feet from entrance to pull box.

D. When conduit stack enter or exit from sweep to a manhole, conduit stack shall separate from common trench at a minimum distance of 35 feet perpendicular to entrance of pull box.

E. Communication conduit stack shall contain a minimum of 4 - four inch conduits.

F. All conduits shall be 15-foot minimum radius in any given section of the 90 degrees conduit sweep. 90 degrees conduit sweep shall be manufacturer-supplied bends of 20 foot length. Determine the total sweep radius by the maximum natural bending capability of each twenty-foot section.

G. Terminate underground conduit stubs with coupling and threaded plug.

3.06 EXPOSED CONDUITS

A. Use galvanized rigid steel (GRS) for exposed conduits.

B. Install conduits straight and true with respect to each other and adjacent construction.

C. Exposed conduits on Public Areas shall be painted to match surrounding areas.

D. Route exposed conduits in such a manner as to obtain the least visibility from public view, along columns and beams, and similar features. Verify routing with the Engineer.

E. Provide separable watertight hub fittings with gasket, separate nylon insulated throat and case hardened locknut.

3.07 SUPPORTS

A. Support conduits in vertical runs not to exceed 5-foot intervals. Use riser supports with clamps for vertical conduit risers.

B. For single conduit runs, use pipe straps with single conduit hangers. Single hole malleable iron clamps may be used for horizontal runs on vertical surfaces. Perforated strap (plumber’s tape) is not acceptable.

C. Multiple Pipe Hangers (Trapeze Type):

1. Fabricate two or more steel hanger rods, a steel horizontal member and U-bolts, clamps, and/or other attachments necessary for securing hanger rods, cable trays and conduits.

2. Hanger Rod – Not smaller than 1/4 inch diameter, threaded full length.
3. Horizontal Member: Steel angles, and channels. Two or more channels may be welded together to form horizontal members of greater strength.

3.08 MANDREL

A. As each section of conduit and duct line is completed between manholes, handholes, and pull boxes, pull mandrel and swab through conduit or duct to remove foreign matter.

B. Draw mandrel through completed conduit run manually without mechanical assistance. If obstructions are encountered which cannot be removed or if conduits do not pass the “usable capacity” mandrel, correct or replace conduit.

C. Correct or replace conduits which have a consistent “hard spot” (indicating possible separation), conduits where joints may damage cable sheaths, or conduits with misaligned junctions or poor conduit joints.

D. During construction, protect partially completed duct lines from entrance of debris by means of suitable caps or plugs.

3.09 PULL CORDS

A. Install pull line in empty (unused/future) conduits. Make pull-line continuous from outlet to outlet, with two (2) feet of slack at each outlet.

B. After conduits are cleaned and mandrelled, install rope and securely seal both ends of conduit with caps.

C. Do not splice pull cords. Leave ample slack length at each end of pull cords.

3.10 FILLING OF OPENINGS

A. Wherever slots, sleeves or other openings are provided in floors or walls for the passage of raceways, including bus ducts, fill such openings as follows:

1. Install fire-resistive filling material to prevent passage of water, smoke and fumes.

2. Where conduits passing through openings are exposed in finished rooms, use filling material that matches, and is flush with, the adjoining finished floor, ceiling or wall.

3.11 CASINGS

A. Install casing in which bore spacers and ductwork will be installed so that inside walls are smooth and free from ridges, projections and seams that might impede the rolling of wheels of bore spacers.

3.12 FIELD QUALITY CONTROL

A. Notify the Engineer for inspection and sign-off of the following installations:
1. Conduits to be direct buried: Notify the Engineer prior to covering.

2. Completed underground installations: Obtain the Engineer’s inspection and acceptance before installation of cable and equipment.

3. Conduits to be embedded in concrete: Obtain the Engineer’s inspection and acceptance before issuing concrete pouring permit.

4. Mandrelling and swabbing (to be witnessed by the Engineer).

5. Installation of pull cords (to be witnessed by the Engineer).

B. Document each mandrelled or swabbed conduit and submit test report.

END OF SECTION
SECTION 16135
OUTLET, JUNCTION, AND PULL BOXES

PART 1 - GENERAL

1.01 DESCRIPTION

A. Section includes requirements for outlet boxes for use with wiring devices and lighting fixture outlets.

1.02 REFERENCE STANDARDS

A. California Code of Regulations (CCR):
   1. Title 24, Part 3, California Electrical Code

B. National Electrical Manufacturers Association (NEMA):
   1. NEMA FB-1 Fittings, Cast Metal Boxes, Conduit Bodies for conduit, Electrical Metallic Tubing (EMT) and Cable
   2. NEMA OS-1 Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports
   3. NEMA 250 Enclosures for Electrical Equipment (1000 Volts max)

C. National Fire Protection Association (NFPA):
   1. NFPA 70 National Electrical Code (NEC)

D. Underwriters Laboratories, Inc. (UL):
   1. UL 514A Metallic Outlet Boxes

1.03 SUBMITTALS

A. Refer to Section 16000, Basic Electrical Requirements, for additional submittals and submittal requirements.

B. Submit manufacturer’s product data on outlet boxes to be used.

PART 2 – PRODUCTS

2.01 GENERAL

A. Furnish electrical boxes of material, finish, type and size indicated and required for location, kind of service, number of wires, and function.

B. Boxes shall have appropriate means to secure covers. Provide boxes complete with accessible covers designed for quick removal and suitable for purpose used;
equip boxes, in which or on which no devices or fixtures are to be installed with flat or raised blank covers as required.

C. Provide neoprene gaskets 1/8 inch thick for boxes subjected to weather.

D. Provide fire resistant gaskets 1/8 inch thick for boxes in tunnels and cross-passages.

E. Furnish necessary adapter plate for mounting devices on light fixtures, brackets, supports, hangers, fittings, bonding jumpers and other accessories required.

F. Concealed and Embedded Junction Boxes: Zinc-coated inside and out.

2.02 STANDARD SHEET METAL BOXES

A. Standard Sheet Metal Boxes: Conform to NEMA OS-1 standard, hot dipped galvanized, one piece drawn steel.

B. Outlet Boxes shall be 4 inch minimum true size and 1-1/2 inches minimum depth unless otherwise specified for the installation. For 1-inch conduit, use boxes 4-11/16-inch minimum trade size. Sectional boxes assembled by means of screws are not acceptable.

C. Use standard galvanized covers, rings and fittings of appropriate type for box or device to be installed. Same thickness as sheet steel boxes.

D. Provide products of commercial quality best suited for purpose indicated or specified.

E. Luminaire and equipment supporting boxes shall be rated for weight of equipment supported.

F. Manufacturer: Appleton, Bowers, Raco, Steel City, or Engineer approved equal.

2.03 CAST BOXES

A. Cast Boxes: Conform to NEMA FB-1. Boxes for exposed switches and receptacles: Cast metal, FS and FD Types.

B. Boxes shall be cast metal type with threaded hubs. Steel or ferrous alloy, with compatible conduit fittings.

C. Use cast metal boxes in moist locations where surface mounted rigid conduit system is used (e.g. storm water lift station sump, above ground prefabricated service booth on interior and exterior surfaces, and for surface mounted weatherproof outlets or devices, regardless of location)

D. Surface Mounted Cast Metal Box: NEMA 250, Type 4, 4X or 6, flat flanged, galvanized cast iron. Furnish cover with ground flange, neoprene gasket, and stainless steel cover screws.

E. Recessed Mounted Cast Metal Box: NEMA 250, Type 3S, heavy duty, galvanized cast iron, recessed cover with neoprene gasket suitable for concrete wall
embedment. Cover shall be provided with stainless steel tamper proof screws. Box shall be drilled and tapped for the number and size of conduits indicated on the Contract Drawings. Use box in tunnels and pedestrian underpasses.

E. In-Ground Cast Metal Box: NEMA 250, Type 6, inside flanged, recessed cover for flush mounting. Galvanized cast iron. Non-skid cover with neoprene gasket and stainless steel screws.

F. Cover Legend: “ELECTRIC”

G. Manufacturer: Appleton, Crouse-Hinds, or Engineer approved equal.

PART 3 - EXECUTION

3.01 OUTLET BOXES

A. Outlet boxes

1. Securely fasten outlet boxes in position and support independent of the conduit system.

2. Install boxes true to the building lines and at equal heights in conformity with mounting heights per NEC and as indicated in the Contract Documents.

3. Boxes shall have only the holes necessary to accommodate the conduits at point of installation.

4. Rigidly secure boxes in position. Set boxes so that the front edge of the box is flush with the finished wall or ceiling line, or not more than 1/8 inch back of same.

5. Offset back-to-back outlets so that a minimum of 6 inches separation.

6. All boxes shall be accessible. Mount boxes with long axis of devices vertical unless otherwise indicated.

7. Locate boxes and box knockouts without interference with reinforcing steel.

B. Lighting Outlet Boxes

1. Exposed installation: Cast metal, not smaller than 4 inches round or square by 2 1/8 inches deep.

2. Embedded and concealed installation: Standard sheet steel boxes approved for intended purpose.

3. Locate outlet boxes to allow luminaries positioned as shown on reflected ceiling plan.
C. Support fixture outlet boxes installed in suspended ceilings supporting acoustical tiles or panels, directly from the structure above, wherever pendent mounted lighting fixtures are installed on the box. Mount boxes independent of ceiling suspension system.

D. Install necessary adapter plate for mounting devices on light fixtures, brackets, supports, hangers, fittings, bonding jumpers and other accessories.

E. Install specified gaskets.

F. Grounding: As specified in Section 16060, Grounding and Bonding. Install grounding jumpers.

3.02 JUNCTION AND PULL BOXES

A. Junction and pull boxes less than 100 cubic inches in size: Cast metal for exposed installation and sheet steel for embedded installation.

B. Junction and pull boxes more than 100 cubic inches in size: Conform to requirements for cabinets, except use recessed cast metal boxes with gasketed covers in tunnels; interface pull boxes at ends of tunnels.

C. Support boxes independently of conduit.

D. Use gang boxes where more than one device is mounted together. Do not use sectional box.

E. Install covers readily accessible after completion of installation.

F. Outlet boxes used as junction boxes: Not smaller than four inches square by 1 1/2 inches deep. Provide flat blank covers.

G. Covers:

1. Same thickness as sheet steel boxes; secured in position by No. 10-24 stainless steel machine screws. Arrange covers to be vandal resistant.

2. Cover for four-inch square box: Provide opening at one side for switch or receptacle; blank at other side.

H. Concealed and Embedded Junction Boxes:

1. Concealed or embedded switch or receptacle boxes: Sheet steel, four inches by 1 1/2 inches deep minimum size.

2. Boxes Set in Concrete:


   b. Plug and mask unused nailing holes and other holes in side or bottom of boxes.
3.03 CLEAN UP

A. After installation, clean boxes placed in concrete.

END OF SECTION
SECTION 16140
CONCRETE HANDHOLES AND PULL BOXES

PART 1 – GENERAL

1.01 DESCRIPTION

A. Section includes requirements for handholes and pull boxes. Handholes and pull boxes are both referred to in this Section as handholes.

1.02 REFERENCE STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. M199 Specification for Precast Reinforced Concrete Manhole Sections

B. California State Department of Transportation (Caltrans) Standard Plans:
   1. ES-8 Pull Box Details

C. California Public Utilities Commission (CPUC) General Orders (G.O.):

D. National Fire Protection Association (NFPA):
   1. NFPA 70 National Electrical Code (NEC)

1.03 SUBMITTALS

A. Refer to Section 16000, Basic Electrical Requirements, for additional submittals and submittal requirements.

B. Submit manufacturer’s product data for supports, covers, grounding, pullboxes and handholes, joint sealing compound, and other materials. Include concrete mix design.

C. Submit shop drawings for fabrication and installation of concrete structures.

D. Submit precast manufacturer’s Certification of Compliance.

1.04 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with NEC and PUC GO No. 128
PART 2 – PRODUCTS

2.01 PRECAST CONCRETE HANDHOLES

A. Unless otherwise indicated, precast concrete handholes shall conform to Caltrans Standard Plan ES-8, No. 3-1/2T, No. 5T, and No. 6T, for H-20 loading, and AASHTO M199.

B. Pullbox No. 3-1/2T shall be “Christy” B1017 or Engineer approved equal, with minimum inside dimensions of 10-5/8 inch wide x 17-1/4 inch long x 24 inches deep. Pullbox shall be provided with bolt down checkered steel lid identified as “ELECTRICAL” or “COMMUNICATIONS”, as required.

C. Pullbox No. 5T shall be “Christy” B1324 or Engineer approved equal, with minimum inside dimensions of 13-1/4 inch wide x 24 inch long x 24 inches deep. Pullbox shall be provided with bolt down checkered steel lid identified as “ELECTRICAL” or “COMMUNICATIONS”, as required.

D. Pullbox No. 6T shall be “Christy” B1730 or Engineer approved equal, with minimum inside dimensions of 17 inch wide x 30 inch long x 24 inches deep. Pullbox shall be provided with bolt down checkered steel lid identified as “ELECTRICAL” or “COMMUNICATIONS”, as required.

E. Where indicated on the Plans provide pullbox “Christy” B2436 or Engineer approved equal, with minimum inside dimensions of 24 inch wide x 36 inch long x 24 inches deep. Pullbox shall be provided with two (2) piece bolt down checkered steel lids, with one of the leads identified as “ELECTRICAL” or “COMMUNICATIONS”, as required.

F. Where indicated on the Plans provide pullbox “Christy” B3048 or Engineer approved equal, with minimum inside dimensions of 30-1/4 inch wide x 48-1/4 inch long x 24 inches deep. Pullbox shall be provided with three (3) piece bolt down checkered steel lids, with center lid identified as “ELECTRICAL” or “COMMUNICATIONS”, as required.

PART 3 – EXECUTION

3.01 CONCRETE HANDHOLES

A. Install handholes flush with concrete platform surface, or flush with sidewalks, curbs, paved areas and other concrete surfaces. Install top of handholes 2 inches above grade in landscaped areas. Seal unused openings with mortar.

B. Install no more than equivalent of three 90 degree bends between pull points.

C. Plug all ends of unused ducts and conduits in handholes. Use plugs manufactured for the purpose.

3.02 HANDHOLE INSTALLATION

A. Excavation and backfill shall be in accordance with Section 02300, Earthwork.
B. Install handhole structures in accordance with the requirements established for precast concrete drainage structures as specified under Section 02630, Storm Drainage System.

C. Set precast handholes on well-compacted soil with minimum of six inches of crushed stone base. Where duct lines enter handholes, sections of duct may be cast in concrete or may enter through square or rectangular opening of suitable dimensions.

D. Review location of handholes and obtain the Engineer’s acceptance before installation of handhole is started.

E. Unless otherwise indicated, install ground rod at each pullbox. Provide grounding braid and grounding accessories for grounding the pullbox cover(s) to the ground rod.

3.03 FIELD QUALITY CONTROL

A. Notify the Engineer for inspection and obtain Engineer’s acceptance of handholes and pull boxes prior to installation of cable and equipment. Make corrections required.

END OF SECTION
SECTION 16250
WIRING DEVICES

PART 1 – GENERAL

1.01 DESCRIPTION
A. Section includes requirements for line voltage wiring devices.

1.02 REFERENCE STANDARDS
A. National Electric Manufacturers Association (NEMA):
   1. NEMA WD 1 General Color Requirements for Wiring Devices
   2. NEMA WD 6 Wiring Devices – Dimensional Specifications
B. National Fire Protection Association (NFPA):
   1. NFPA 70 National Electrical Code (NEC)
C. Underwriters Laboratories Inc. (UL):
   1. UL 20 General-Use Snap Switches
   2. UL 50 Enclosures for Electrical Equipment, Non-Environmental Considerations
   3. UL 94 Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
   4. UL 486A&B Wire Connectors
   5. UL 498 Attachment Plugs and Receptacles
   6. UL 514A Metallic Outlet Boxes
   7. UL 514B Conduit, Tubing, and Cable Fittings
   8. UL 943 Ground-Fault Circuit-Interrupters

1.03 SUBMITTALS
A. Refer to Section 16000, Basic Electrical Requirements, for additional submittals and submittal requirements.
B. Submit shop drawings.
C. Submit manufacturer product data for all types of wiring devices to be used.
PART 2 – PRODUCTS

2.01 DEVICES

A. Provide wiring devices conforming to the following UL Standards: 20, 50, 94, 486A-486B, 498, 514A, 514B and 943. Wiring devices shall also conform to NEMA WD 1 and WD 6.

B. Provide wiring devices indicated. Provide all similar devices of same manufacturer. Provide devices and device plates of the color and finish specified in the Contract Documents.

2.02 SWITCHES, FLUSH TUMBLER TYPE

A. General Requirements:

1. Unless otherwise specified or shown, use quiet type switches with ivory handles, rated 120/277 Volts ac and conforming to NEMA WD 1. Wiring methods shall be as specified in Section 16100, Wiring Methods.

2. Do not load switches more than 80 percent of their current rating.

3. Equip switches with metal mounting yoke with plaster ears, insulated from mechanism and fastened to switch body using bolts, screws, rivets or other substantial means to meet test requirements.

4. Provide green-colored equipment grounding screw on yoke. Switches shall be back or side wired with terminals of screw or combination screw-clamp type. Terminal screws shall be No. 8 or larger, captive or terminal type with access hole for back wiring. Wiring terminals shall be able to receive and hold proper wire size.

B. Standard Type Switches:

1. Tumbler type, totally enclosed, heavy duty. Catalog numbers listed below are for 120/277 Volt, 20 Amps, with ivory handles. Provide different color if specified in the Contract Documents. Where required, furnish 2 pole, 3 way and 4 way switches, and lock switches of comparable grade. Provide one key for each lock switch.

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or Engineer approved equal.
C. Weatherproof Switches:

1. Provide switch in cast metal box: Appleton or Crouse-Hinds Type FS or FD, or Engineer approved equal.

2. Cover and gasket: Appleton #FSK-1V, Crouse-Hinds #DS-181, or Engineer approved equal combination.

2.03 RECEPTACLES

A. Power receptacles and switches for general purpose circuits shall be manufactured per NEMA Specifications, rated as follows:

1. General purpose receptacles: NEMA 5-15R or 5-20R

2. Dedicated Receptacles: NEMA 5-20R

B. Receptacle bodies and bases: Fire resistant non-absorptive hot molded phenolic composition material or approved equivalent with metal plaster ears integral with supporting member.

C. Provide receptacles with light colored terminal facilities for neutral connections, amber or brass colored for phase conductor connections and green colored hexagonal machine screws for equipment grounding conductor and connections.

D. Receptacle contacts including grounding contact: Double grip bronze type with spring steel backup clips to ensure both sides of each male prong of plug will be in firm contact.

E. Provide receptacles with self-grounding clip or mounting strap green screws.

F. Ground fault circuit interrupter duplex receptacles: 120 Volt, 60Hz, 20 ampere with built-in test, reset buttons. Interrupt circuit within 1/30 second on a five milliampere earth leakage current. Maximum circuit capacity 20 amperes. Straight blade, heavy duty, industrial specification grade.

G. Ground Fault Circuit Interrupter Duplex Outlet (GFI): 20 amp, 125 Volt ac, 3 wire, grounding type, straight blade. Ivory color: Hubbell # GF5362IA, Pass & Seymour # 2095-SI, Leviton #7899-SGI, or Engineer approved equal.

H. Weatherproof Metallic Covers for Duplex GFI Receptacles: WPO listed, covers with this listing shall meet NFPA 70, Section 406.8(A) and 406.8(B) as applicable, and UL 514A receptacle requirements for wet location that is rated for wet location for either cover closed and/or cover open with device in use (“open”):

1. Surface Mounted: Appleton or Crouse-Hinds Type FS or FD cast box or equal with rated for wet location metal cover with gasket:

   a. Appleton cover type FSK, Hubbell HBL5206WO, or Engineer approved equal
2.04 DEVICE COVER PLATES

A. Interior plates: Vandal resistance, stainless steel 14 gauge.

B. Exterior plates: Device cover plates shall be cast aluminum with self-closing hinged cover, rated for damp location.

C. Gang Plates: Use gang type plates for multiple units.

D. Screws: Vandal resistance stainless steel.

PART 3 – EXECUTION

3.01 GENERAL REQUIREMENTS

A. Install all wiring devices indicated complete with cover plates. Cover plates shall fit snugly against finished surfaces and line-up true with adjacent building lines, and be symmetrical in location and appearance.

B. Unless otherwise noted on the Contract Drawings, receptacles shall be installed in the vertical position with the grounding pin down.

END OF SECTION
SECTION 16450
PANELBOARDS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Section includes requirements for panelboards providing fault interrupting capability and overcurrent protective devices.

1.02 REFERENCE STANDARDS

A. California Code of Regulations (CCR):
   1. Title 24, Part 3, California Electrical Code

B. National Electrical Manufacturers Association (NEMA):
   1. NEMA AB1 Molded-Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures
   2. NEMA AB-4 Guidelines for Inspection and Preventative Maintenance Of Molded Circuit Breakers Used in Commercial and Industrial Applications
   3. NEMA PB1.1 General Instructions for Proper Installation, Operation, and Maintenance of Panelboards Rated 600 Volts or Less
   4. NEMA PB1 Panelboards
   5. NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum)

C. International Electrical Testing Association (NETA):
   1. NETA ATS Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

D. National Fire Protection Association (NFPA):
   1. NFPA 70 National Electrical Code (NEC)

E. Underwriters Laboratories Inc. (UL):
   1. UL 50 Enclosures for Electrical Equipment, Non-Environmental Considerations
   2. UL 67 Panelboards
   3. UL486A-486B Wire Connectors
4. UL 489 Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures

5. UL 943 Ground-Fault Circuit-Interrupters

1.03 SUBMITTALS

A. Refer to Section 16000, Basic Electrical Requirements, for additional submittals and submittal requirements.

B. Product Data: Submit for each type of panelboard, overcurrent protective device, transient voltage surge suppressor (TVSS) device, accessory, and component indicated. Include dimensions and manufacturers’ technical data on features, performance, electrical characteristics, ratings, and finishes.

C. Shop Drawings: Submit for each panelboard and related equipment.

1. Dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings. Include the following:

   a. Enclosure types and details for types other than NEMA 250, Type 1.

   b. Bus configuration, current, and voltage ratings.

   c. Short-circuit current rating of panelboards and overcurrent protective devices.

   d. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

2. Wiring Diagrams: Diagram power, signal, and control wiring and differentiate between manufacturer-installed and field-installed wiring.

D. Qualification Data: Submit data for testing agencies indicating that they comply with qualifications specified under Quality Assurance herein.

E. Test Procedure for Overcurrent Protective Devices: Test procedures shall comply with NEMA AB-4 guidelines.

F. Field Test Reports: Submit written test reports and include the following:

1. Test procedures used

2. Test results that comply with requirements

3. Results of failed tests and corrective action taken to achieve test results that comply with requirements

G. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.
H. Maintenance Data: Submit operations and maintenance manuals for panelboards and components as specified in Section 01730, Operations and Maintenance Manuals.

1. Manufacturer’s written instructions for testing and adjusting overcurrent protective devices.

2. Time-current curves, including selectable ranges for each type of overcurrent protective device.

1.04 COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, and encumbrances to workspace clearance requirements.

1.05 MAINTENANCE MATERIALS

A. Keys: Furnish six spare keys of each type of panelboard cabinet lock.

B. Accessory Set: Furnish tools and miscellaneous items required for test, inspection, maintenance, and operation.

PART 2 - PRODUCTS

2.01 GENERAL

A. Panelboards shall comply with UL 67 requirements. Include the following panelboards:

1. Lighting and appliance branch-circuit panelboards

2. Distribution panelboards

2.02 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers listed.

B. Panelboards, Overcurrent Protective Devices, and Accessories:

1. Eaton Corp.; Cutler-Hammer Products

2. General Electric Co.; Electrical Distribution & Control Division


4. Square D Company

5. Or Engineer approved equal
2.03 FABRICATION AND FEATURES

A. Enclosures: Surface-mounted cabinets. NEMA PB 1, Type 1, to meet environmental conditions at installed location.

B. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.

C. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.

D. Finish: Manufacturer's standard enamel finish over corrosion-resistant treatment or primer coat.

E. Directory Card: With transparent protective cover, mounted inside metal frame, inside panelboard door.


G. Main and Neutral Lugs: Mechanical type suitable for use with conductor material.

H. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment ground conductors; bonded to box.

I. Service Equipment Label: UL labeled for use as service equipment for panelboards with main service disconnect switches.

J. Future Devices: Mounting brackets, bus connections, and necessary appurtenances required for future installation of devices.

K. Skirt for Surface-Mounted Panelboards: Same gauge and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.

2.04 PANELBOARD SHORT-CIRCUIT RATING

A. Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.05 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

B. Doors: Front mounted with concealed hinges; secured with flush latch with tumbler lock; keyed alike.

2.06 DISTRIBUTION PANELBOARDS

A. Doors: Front mounted, except omit in fused-switch panelboards; secured with vault-type latch with tumbler lock; keyed alike.

B. Main Overcurrent Protective Devices: Circuit breaker.

C. Branch overcurrent protective devices shall be one of the following:
1. For Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.

2. For Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers.

2.07 OVERCURRENT PROTECTIVE DEVICES

A. General: Devices shall be the latest approved design as manufactured by a nationally recognized manufacturer and in conformity with applicable standards and listings of nationally recognized testing laboratories. Devices shall comply with UL requirements 489, 50, 67 and 943.

1. Overcurrent protective devices shall be molded-case circuit breakers as specified herein.

B. Molded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.


C. Breakers shall be bolt-on type suitable for individual as well as panelboard mounting. Breakers shall be bolt-on type, no “plug-on” type panelboard breakers allowed.

D. Breakers shall meet current National Electrical Manufacturers Association (NEMA) and Underwriters Laboratories (UL) specifications as applicable to frame size, standard rating, and interrupting capability.

E. Breakers shall be one, two, or three pole as scheduled, and shall be of the quick-make, quick-break thermal magnetic type. They shall be trip free to prevent closing when a fault exists. The handle positions shall clearly indicate “ON”, “OFF”, and “TRIPPED” positions. Two pole breakers shall be physically the same size as two single-pole breakers, thereby permitting any combination of one, two, or three pole breakers.

F. Operating handle shall open and close all poles simultaneously on a multi-pole breaker.

G. Provide Class A (5ma sensitivity) breakers where GFI Type breakers are required.

H. Breaker Features and Accessories. Standard frame sizes, trip ratings, and number of poles.

I. Lugs: Mechanical style, suitable for number, size, trip ratings, and material of conductors.

J. Size overcurrent protective devices as shown on the panel schedule in the Contract Documents or as required by the load being served. Provide separate neutral conductors for circuits protected by GFI breakers.
2.08 FEATURES

A. Fungus Proofing: Permanent fungicidal treatment for panelboard interior, including overcurrent protective devices and other components.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install panelboards and accessories according to NEMA PB 1.1.

B. Comply with mounting and anchoring requirements for seismic zone 4 location.

C. Mounting Heights: Top of trim 74 inches above finished floor, unless otherwise indicated.

D. Mounting: Plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish.

E. Circuit Directory: Refer to Section 16000, Basic Electrical Requirements. Create a directory to indicate installed circuit loads after balancing panelboard loads.

F. Install filler plates in unused spaces.

G. Wiring in Panelboard Gutters: Arrange conductors into groups and bundle and wrap with wire ties after completing load balancing.

3.02 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Section 16000, Basic Electrical Requirements.

3.03 CONNECTIONS

A. Install equipment grounding connections for panelboards with ground continuity to main electrical ground bus.

B. Tighten electrical connectors and terminals according to manufacturer’s published torque-tightening values. If manufacturer’s torque values are not indicated, use those specified in UL 486A and UL 486B.

3.04 FIELD QUALITY CONTROL

A. Testing: After installing panelboards and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

   1. Procedures: Perform each visual and mechanical inspection and electrical test indicated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.

   2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
B. Balancing Loads:  When all loads are connected, measure load balancing and make circuit changes as follows:

1. Measure as directed during period of normal system loading.

2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data-processing, computing, transmitting, and receiving equipment.

3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.

4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

C. Infrared Scanning: When all loads are connected, perform an infrared scan of each panelboard. Remove panel fronts so joints and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.

2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

3. Record of Infrared Scanning: Prepare a certified report that identifies panelboards checked and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.05 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

3.06 CLEANING

A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.
SECTION 16800
SITE LIGHTING

PART 1 – GENERAL

1.01 DESCRIPTION
A. Section includes requirements for site lighting system, including lighting control and protection components.

1.02 REFERENCE STANDARDS
A. American National Standards Institute (ANSI):
   1. ANSI C82.4 Ballasts for High-Intensity-Discharge and Low-Pressure Sodium Lamps (Multiple-Supply Type)
B. Institute of Electrical and Electronics Engineers (IEEE):
C. National Fire Protection Association (NFPA):
   1. NFPA 70 National Electrical Code (NEC)
D. Underwriters Laboratories (UL):
   1. UL 1029 High-Intensity-Discharge Lamp Ballasts
   2. UL 1598 Luminaires

1.03 SUBMITTALS
A. Refer to Section 16000, Basic Electrical Requirements, for additional submittals and submittal requirements.
B. Submit shop drawings including dimensions and components for each luminaire which is not a standard product of the manufacturer. Submit shop drawings of the lighting control cabinet, including layout drawing, control schematic, and wiring diagram.
C. Submit product data including dimensions, ratings, and performance data.
D. Submit test reports indicating measured illumination levels.
E. Manufacturer’s Instructions: Indicate application conditions and limitations of use stipulated by product testing agency.
F. Manufacturer’s Instructions: Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
G. Maintenance Data: Submit maintenance data including instructions for maintaining luminaires.

1.04 REGULATORY REQUIREMENTS

A. Conform to requirements of NEC.

B. Furnish products listed and classified by a nationally recognized testing laboratory.

PART 2 – PRODUCTS

2.01 LIGHTING FIXTURES - GENERAL

A. Refer to Contract Drawings for Lighting Fixture Schedule. Provide lamp type as indicated on the Contract Drawings and as specified herein.

B. All lighting fixtures shall have a polycarbonate shield for vandalism. All fixtures shall be waterproof and vandal-proof.

C. The exterior lighting fixtures for the temporary station platforms shall be high pressure sodium vapor as indicated on the Contract Drawings. Fixtures shall have fully adjustable bilateral reflectors. The housing shall be constructed of extruded aluminum with an extruded aluminum hinged door for access to the lamp. The lamp holder shall be of the grip-tight mogul socket. Fixture voltage shall be selected to coordinate with the existing source available.

D. Luminares shall comply with UL 1598. High intensity discharge ballast shall comply with UL 1029 and ANSI C82.4.

E. The finish of exterior luminaires shall be corrosion resistant, electrostatically applied on painted components.

F. Fixtures shall have ballasts pre-wired with high power factor and designed for minus 20 degree F, or below, starting. The capacitor shall be separate and replaceable. The starting current of the ballast shall be less than the normal running current. The ballasts shall be of the high endurance type with a 3 year written manufacturer’s guarantee covering damage to the ballasts due to lamp failures in open or short circuit conditions. Ballast shall have a protect feature which will prevent pulses to burn out lamps.

G. Fixtures shall be listed by a nationally recognized testing laboratory for wet locations.

H. Gaskets shall be high quality, high temperature gaskets providing positive weatherproof seals.

I. Furnish mounting hardware and appurtenances with each fixture.
2.02 FIXTURE MOUNTING HARDWARE

A. Lighting fixtures shall be designed with mounting brackets to provide the nominal mounting heights of luminaires as indicated on the Contract Drawings.

B. Arms, mounting brackets, lighting poles, bases, and all hardware shall be from the same manufacturer as lighting fixtures. All shall be compatible in appearance, finish, and assembly.

C. Where applicable, lighting poles shall be provided with grounding lugs capable of accepting a #2 AWG tap from the OCS (Overhead Catenary System) system counterpoise ground. This shall be in addition to the ground lug provided for connection to the equipment grounding conductor and supplementary ground.

D. Mounting brackets for temporary station platform lights shall be suitable for wood pole mounting, fabricated from standard pipes, with an insulated wire inlet and rod to secure arm to wood pole. Wood pole shall be ANSI Class 5, of the length indicated on the Contract Drawings.

2.03 LIGHTING CONTROL EQUIPMENT

A. Lighting control cabinet shall be NEMA Type 12 for indoor installation and NEMA Type 4 for outdoor installation. Cabinets shall be designed for wall mounting or shall be self standing, with dimensions as indicated on the Contract Drawings. Outdoor cabinets shall have outer and inner doors, backpanel, and hasp for padlocking.

1. Time Switches: Digital type, two channels, with 365 days advance single holiday and seasonal schedule. Time switch clock input shall be 120 volts, 60 hertz, and shall be provided with two DPDT contacts rated a minimum of 10 amperes continuous duty. Time switch shall be able to retain the schedule for 40 years without power.

2. Photoelectric Unit: Furnish photoelectric unit and necessary hardware suitable for mounting where required on the Drawings.

3. Control Relays: Control relays shall be general purpose, blade type, 3PDT contact configuration with neon indicating light, rated minimum of 10 amperes at 240VAC. Provide matching socket base with hold down clips.

4. Selector switch: Selector switch shall be NEMA 4X, oiltight/watertight, with contact block arrangement as required on the Contract Drawings.

5. Lighting contactors: Lighting contactors shall be magnetically held, multi-pole, with coil rated at 120VAC, 60 hertz. Contact rating shall be a minimum of 30 amperes continuous. Number of contacts shall be as indicated on the Contract Drawings.

6. Lightning arrester: Lightning arrester shall be a secondary surge arrester for electrical wiring.
7. Terminal blocks: Terminal blocks shall be provided for all incoming and outgoing circuits. Terminal blocks shall be rated 600 volts, and shall be UL listed. Terminal blocks for incoming circuits shall be suitable for wire sizes ranging from #20 AWG to #6 AWG. Terminal blocks for outgoing circuits shall be suitable for wiring ranging from #8 AWG to #4 AWG.

8. Wire management: Plastic wire duct with slotted sidewall and with cover, sized as indicated on the Contract Drawings or as required.

B. Control equipment shall provide components and connections which will allow automatic control of the lighting system. The controls shall provide on-off control of the lighting in response to two modes of operation:

1. Manual

2. Automatic: In the automatic mode, the primary control device shall be the photocell unit. The time clock shall be wired into the control circuit such that certain lights may be turned off for a preset period of time during the normal photocell on period. The time clock controlled off operation shall be completely programmable for periods of time as short as 15 minutes and the setting shall be visible on the face of the time clock.

PART 3 – EXECUTION

3.01 GENERAL

A. Provide grounding to fixtures in accordance with Section 16060, Grounding and Bonding. Wiring methods and devices shall be in accordance with Sections 16100, Wiring Methods, and 16250, Wiring Devices. Handholes and pull boxes for running wiring to the luminaires and posts shall be in accordance with Section 16138, Concrete Handholes and Pull Boxes.

3.02 LIGHTING FIXTURES

A. Install in accordance with manufacturers’ instructions.

B. Install lighting poles at locations indicated on the Contract Drawings. Locations on Contract Drawings are diagrammatic. Obtain Engineer’s approval of exact locations in field.

C. Install lamps in each luminaire.

D. Bond luminaire, metal accessories, and metal poles to branch circuit equipment grounding conductor. Provide supplementary grounding electrode in the adjacent handhole or at the pole base where indicated on the Contract Drawings. Provide additional bonding to the OCS system counterpoise ground where indicated on the Contract Drawings. Refer to Section 016060, Grounding and Bonding.

E. Avoid interference with and provide clearance for equipment. Where the indicated locations for the lighting fixtures conflict with the locations for
equipment, change the locations for the lighting fixtures by a minimum distance necessary as approved by the Engineer. For purposes of this Section, clearances and interferences will be as defined in the NESC.

F. Photoelectric controls shall provide control to the lighting contactors for the lighting systems and shall be powered independent of the wiring to the luminaire ballast system.

3.03 LIGHTING CONTROL DEVICES

A. Apply labels or stencil to control components to identify components and their purpose.

B. Lightning Arrestor: Install lightning arrestor within the control cabinet.

3.04 FIELD QUALITY CONTROL

A. Take light meter readings in the presence of the Engineer at night to ensure proper lighting levels of all lighting systems. Provide the labor and equipment to make any required adjustments at this time. Notify the Engineer at least 48 hours prior to performing this test. This test shall be accomplished in the presence of the Engineer. Submit the test results to the Engineer in writing prior to Final Inspection. Record results on the Project Record Drawings.

B. After completion of the work, place illumination system in operation. Final acceptance will not be made until the system has operated satisfactorily for a period of not less than 30 days from the date designated by the Engineer. This test period shall be included with the specified Contract time. Operation of the system shall not in any way be construed as an acceptance of the system or any part of it or as a waiver of any of the provisions of the Contract. The Contractor shall be responsible for the system during this period of operation and shall make any adjustments or repairs which may be required and remedy defects or damage which may occur.

END OF SECTION
SECTION 17000
BASIC COMMUNICATIONS TECHNICAL REQUIREMENTS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Section provides an overview of technical requirements, engineering guidelines, technical constraints, and general conditions to be followed throughout the design of the Station Communications System.

B. Technical requirements specific to each communications subsystem are in each of the subsystem Specification Sections within Division 17, Station Communications.

1.02 GENERAL

A. The provisions of this Section apply to all sections within the Division 17, Station Communications, except as otherwise specified. This and all other Specification Sections are collectively referred to Specifications.

1.03 REFERENCE STANDARDS

A. Building Industry Consulting Service International (BICSI):
   1. Registration as Communications Distribution Designer (RCDD)

B. Institute of Electrical and Electronic Engineers (IEEE):
   1. 200 Reference Designations for Electrical and Electronics Part and Equipment

C. Military Standard (MIL-STD):
   1. 472F Human Engineering

1.04 SUBMITTALS

A. Design Review Submittals - General Requirements
   1. Submit Design Review Submittals consisting of a complete design description, including detailed drawings, specifications, and submittals of all subsystems and elements within the subsystem. If not governed by codes and regulations, as a minimum, calculation, test procedure, final drawing, and submittal shall be reviewed, signed and sealed by a BICSI Registered Communications Distribution Designer (RCDD). For submittals involving engineering design services required by governing codes and regulations; system design, load and design calculations shall be sealed and signed by a professional engineer, currently registered in the State of California, for the corresponding discipline. The final design document shall contain sufficient details for construction.
2. Include in each submittal phase all materials, equipment, assembly and installation required to carry out the functions and purposes indicated in the Specifications, and to make the system suitable for the purpose for which it is intended, whether or not such materials, equipment, assembly and installation are specifically indicated in the requirements of these Specifications.

3. The Engineer will not approve the proposed design that fails to achieve the result intended by the requirements of this Section or is not in accordance with sound engineering principles. Revise the design until it meets with Engineer approval in accordance with the requirements of these Specifications.

4. Approval or disapproval by the Engineer, or failure to approve or disapprove shall not relieve the Contractor of any responsibilities including the responsibility to provide a sound and practicable system design, suited for the intended purpose outlined in the Specifications and responsibility for accuracy and agreement of dimensions and details.

5. Coordinate each submittal with the requirements of the Work, placing particular emphasis upon assuring that each submittal of one trade is compatible with other submittals of related work. Ensure submittal is complete with all relevant data required for review, including, as a minimum the following:
   
a. The correctness of the drawings, for shop fits and field connections, and for the results obtained by the use of such drawings

b. Verification of catalog numbers, and similar data

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

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

e. Determination of accuracy and completeness of dimensions and quantities

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

g. Safety precautions

h. Errors or omissions on submittals

i. Coordination and performance of work of all trades

j. Identification of deviation(s) from Contract requirements

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

7. Where requirements posed by individual subsystems, as defined in other Sections of these Specifications, are different or greater than those specified in this Section, those other requirements shall be deemed to augment the requirements specified herein. All requests for design variations and exceptions from specified standards must be submitted to the Engineer for review and approval.

8. Design Review requirements for each submittal: Preliminary and Final are defined within the individual subsystem Sections. Preliminary Design packages shall be individual submittals or each subsystem, where the Final Design package is one complete submittal sufficient to provide all the required details for construction, overall system integration, and operation. Requests for design variations and exceptions must be submitted not later than the Final Design review and approved by the Owner in writing before the affected Design Units could be released for construction.

9. Order the designated equipment and material only after Engineer’s approval of the individual subsystem Preliminary Design submittal, which includes design, calculations, operation as well as the entire product data for that subsystem.

B. Preliminary Design Technical Requirements

1. Submit Preliminary Design packages to satisfy the requirement outlined herein and the subject subsystem section of these Specifications. Communications Preliminary Design shall be required for the following subsystems, except for those subsystems which are not included in the Contract:

   a. Communications Facilities
   b. Communications Cabinets
   c. Conduit / Raceway / Ductbank Subsystem
   d. Communications Cable
   e. Power Cable
   f. Fiber Optics Cable Subsystem
   g. Public Address (PA) Subsystem
   h. Visual Message Sign (VMS) Subsystem
i. CCTV (Security Cameras)
j. Ticket Vending Machines (TVMs)
k. Clipper Network Card Interface Devices (CIDs)
l. Station Network Subsystem
m. Power Supplies and Distribution
n. Grounding and Protection
o. Miscellaneous Items

2. Each Preliminary Design package shall be organized to include the following headings and information:


b. Reference Material: List of relevant references and standards.

c. Specification compliance matrix table acknowledging and referencing the Contractor’s conformance to each technical requirement clause of every subsystem specifications Section.

d. Design Description: As a minimum shall include the subsystem description, detailed design and interface information, all performance, functionality and operational description, as well as details such as the cable and equipment identification.

e. Interface Requirements: Identify all required interfaces with other communications and non-communications systems and subsystems. The Preliminary Design shall include the following:

1) Interfaces between Work performed under this Contract and any other Communications contracts, such as, Rail Operations Control System (ROCS) and Passenger Information System located at the Central Control Facility (CCF), Alarm Points and any other required interfaces.

2) Interfaces between the subsystems defined under this Contract. Examples are PAS and LAN; WAN and LAN, TVM and LAN; all the other required interfaces defined in these Specifications.

3) Identification and description of any inquired hardware and software modifications or additions to existing subsystems equipment.

4) Identification of all external interfaces, including those to facilities and equipment provided by others. Interface
examples include power, cable facilities, discreet signals, voice, and data; and the format/coding of the exchanged data.

5) Interfaces between the systems. This includes both Communications and Signals.

6) Interfaces between existing systems and Work performed under this contract, between subsystems and all other interfaces which include media converters and/or protocol converters shall be identified and described in detail.

f. Equipment List: Submit a table or list of model and part numbers for all proposed equipment and materials to be used for individual subsystems. Include the expected lead-time for each item while identifying in boldface type the ones with greater than 30 days. The table or list shall be grouped for each subsystem with functional descriptions of equipment or material included. Quantities and locations shall be included.

g. Product Data Sheet: Submit product information in sufficient detail to determine if the component meets these Specifications. The models to be used in the contract shall be explicitly identified in the product data sheet.

h. Calculations: Provide all the required signed and sealed calculations as outlined in the subject subsystem section.

i. Phasing and Cutovers: Identification and description of all major system cutover events or integration activities describing techniques, methods, duration and procedures.

j. Certifications, Registration, and Resumes: Provide a copy of all the required certifications, registrations and resumes as outlined in the subject subsystem section.

k. Drawings: Electrical, mechanical, block and functional diagrams with corresponding parts list.

C. Final Design Technical Requirements

1. Submit one complete Final Design package no later than 60 days after Engineer’s approval of all the Preliminary Design submittals. Obtain Engineer’s approval of all individual Preliminary Design submittals prior to submitting the Final Design submittal package.

2. The Final Design Submittal Package shall be organized to include the following final design information:

a. Engineer approved and updated versions of all previously submitted design review materials. Updated material shall represent complete design, final calculations; detailed product
and component level parts list, drawings, phasing and interface details required for construction, intended network, software and configuration settings. All the new and revised sections of the subsystem Preliminary Design shall be marked with revision bars to reflect the changes.

b. Updated product submittals for all, materials and components for which product submittals were not previously submitted and Engineer approved.

c. Complete Drawing index

d. Complete cable identification and equipment labels

e. Complete wiring diagrams for all equipment to be installed, modified, upgraded, or interfaced

f. Top level mechanical drawings, if applicable

g. Grounding and protection details

h. Power panel schedule and distribution

D. Installation Work Plans and Detailed Documentation

1. Submit complete installation Work Plan and detailed documentation and drawings no later than 60 days prior to the scheduled installation date for each location and each subsystem.

2. Obtain Engineer’s approval of the Final Design submittal prior to submitting installation detailed documentation applicable to a subsystem.

3. Organize the Installation Work Plan package to include the following headings and information:

   a. Scope and description of Work

   b. Prerequisites

   c. Tools

   d. Installation personnel and their roles

   e. Safety rules, regulations, procedures, and requirements

   f. Permits, licenses, training including confined space, and certifications

   g. Planned access dates and times for each location, the Engineer’s resources required for each location, and Operational Impact

   h. Daily Preparation Procedures and Clean-up
i. Storage, staging facilities, security, and the overall job-site security

j. Installation procedures shall include each subsystem hardware and software components including any software and configuration settings and changes.

k. Installation drawings:
   i. Corresponding subsystem design review drawings with updates and details. Include detailed physical layout drawings with material list keyed to the layouts.
   ii. Cable and conduit schedules that show exactly where each cable is to be installed. Include and identify raceways, cable trays, conduit, junction boxes, pull boxes, manholes, hand-holes, and floor boxes. The cable and conduit schedules shall be accompanied with the corresponding voltage drop, cable gauge and conduit fill calculations, which shall be approved by the Engineer.
   iii. Cable and wiring connectors and terminal assignments.
   iv. Wiring diagrams to include terminal blocks, power panel details, Local Distribution Frames (LDF), Main Distribution Frame (MDF), and any additional wiring required for a complete design.
   v. Names and labels for all equipment including every wire, cable, connector, terminal and rack.
   vi. Electrical power diagrams and panel and power strip schedules.
   vii. Mounting, securing, seismic protection and installation details for all equipment and materials.
   viii. For racks in which equipment will be installed, rack-face elevations with all intra-rack and inter-rack wiring and cabling to be installed.
   ix. Power connections, panel schedules and grounding/protection connections.
   x. Location of all safety and hazard warning signs and labels.
   xi. Site Survey information.

E. Product Samples as required in individual subsystem Sections or where requested by Engineer.
F. Testing and Inspection

1. Submit Test Program no later than 60 days after Engineer’s Final Design approval, outlining Contractor’s overall testing strategy and schedule.
   a. The program shall include a list of all tests to be performed for all subsystems and integral equipment and materials to meet the requirements of these Specifications.
   b. The program shall include individual subsystem test plans.
   c. At a minimum, the test program shall cover the following testing activities:
      i. Factory Testing
      ii. Inspection
      iii. Field Equipment and Subsystem Testing
      iv. End-to-End Acceptance Test
      v. System Integration Test
   d. The test program shall include a list all the required tests per subsystem, to be performed in order to meet the requirements of these Specifications. This list shall be organized to include:
      i. Type of test
      ii. Tools and Test Equipment
      iii. Prerequisites
      iv. Pass and fail criteria
      v. Personnel and laboratory requirements
      vi. Required Cutover and Phasing: The cutover sequences shall be accompanied with the corresponding fallback procedures (should something go wrong).
      vii. Expected Impacts (Outages, Operational, Environmental, and Traffic, Revenue) and recovery Plan when required.
      viii. Engineer’s resources
      ix. Scheduled date and expected duration
      x. Additional Comments and notes

2. Submit test and inspection procedures no later than 60 days prior to the scheduled activity. All the required test and inspection procedure
submittals shall be detailed and organized to be consistent and include, but not be limited to the following heading and information:

a. Scope and Purpose: Clearly state the scope, case, and conditions the procedure tests.

b. Prerequisites: Describe test environment and the prerequisites, including access, availability, and equipment configuration for each group of functions.

c. References

d. Tools: List test equipment and tools, with calibration data for each item.

e. Personnel: List test participants and their roles.

f. Procedure: Contain enumerated step-by-step procedures. This shall include regression test and Pass and Fail Criteria.

g. Drawings: Include detailed drawings depicting test setup. This shall include list of equipment, parts and material used and tested.

h. A Test Data Form that includes space to record the tools with calibration date, environmental condition during the test, i.e., rainy, cloudy, and temperature, test measurement, pass and fail criteria and space to record the pass and fail outcome and the signature of the test engineer and a test witness.

3. The Test Exception Form shall be used to record the identifier of the defect report and problem report generated as a result of faults or problems detected during the test. All the troubleshooting techniques and corrective actions shall be documented on this sheet. All found defects and problems, occurred as a result of the Contractor’s deficient design or implementation, shall be rectified and retested to the satisfaction of the Owner representative.

G. Test and Inspection Records and Reports

1. Submit all test and inspection records and reports within one week of completion of the corresponding test.

2. Test and inspection records shall be reviewed, signed and sealed to certify adherence to design requirements and standards.

3. Organize test and inspection report submittal to include the following headings and information:

   a. Purpose/Introduction: Defines the submittal scope.
b. Test/Inspection Results Summary: Include measurements, results, problem areas, workarounds, troubleshooting, and exceptions.

c. Open Items: Identify any open items requiring resolution. Include the corrective action to resolve the open items.

d. Conclusion: This section shall document the Contractor’s review and how the test and inspection meets the system design and performance requirements outlined in the Specifications.

e. Completed Test and Inspection Records: A completed, signed, and dated test/inspection procedure sheets, as well as a defect/problem report for each fault/problem found during the testing.

H. As-built Documentation: In addition to the requirements of Section 01720, Contract Record Documents, submit the following documentation. Submit as-built versions of the following documentation sealed, as a minimum by a Registered Communications Distribution Designer (RCDD). Documentation with engineering design governed by codes and regulations shall be sealed and signed in blue ink by a professional engineer, currently registered in the State of California, for the discipline involved. Submit as outlined herein for the communications system:

1. Equipment inventory, with serial numbers including delivered, installed and spares.

2. Drawings as a minimum shall include those submitted under Final Design, installation and test procedure documents. The As Built drawings shall be numbered and grouped in accordance with Caltrain AutoCAD standards.

3. Final customized software data and source codes.

4. Final alarm, hardware, network and software configurations including required configurations of any operating systems to allow the system to properly function.

5. Final equipment configuration, provisioning, programming and settings.

6. Technical Specification to reflect the final system design implemented in the field.

PART 2 – PRODUCTS

Not Used. See individual Specification Sections under Division 17.
PART 3 - EXECUTION

3.01 INSTALLATION AND GENERAL DESIGN REQUIREMENTS

A. Refer to the Contract Drawings for information regarding Caltrain facilities and space in Caltrain facilities.

B. Environmental condition to which equipment shall be designed is defined in these Specifications.

C. Comply with IEEE 200.

D. Operation and Maintenance

1. Operating and maintenance safety shall be the highest consideration in equipment and subsystem design, construction, and installation.

2. Human Factors for operations and maintenance of equipment configuration and positioning shall:
   b. User interface equipment and characteristics such as display devices, preferred viewing angles, lettering, control devices and their tactile characteristics, indicators, use of colors, and use of audible indicators shall be consistent with MIL-STD-1472.

3. Where applicable, equipment and design shall comply with ADA requirements.

E. Continued Operation of Rail System

1. The Caltrain Rail System conducts Revenue Operations seven days a week. The existing Communications systems and the CCF (Central Control Facility) are in use 24 hours, seven days a week.

2. Installation, replacement, testing or modification of equipment or software during implementation of any new Communications System shall not disrupt continued operation of the Rail System, including operation of the CCF and Fare Collection system.

3. During revenue or non-revenue hours, any disruption to the existing Communications systems and CCF shall be minimized. To the extent possible, no more than a single node shall be unavailable through the existing Communications systems and CCF at any point in time with prior to the Engineer’s approval.

4. Coordinate with and obtain necessary approvals from authorities having jurisdiction for shutdowns, temporary diversions, utility relocations, temporary sidewalk closures, and pedestrian detours.

5. Refer to Sections 01011, Work Planning, and 01040, Work Hours and Track Access. Track access time is limited. Coordinate and comply with
requirements specified in Division 1, General Requirements, regarding track access and any work that could potentially interfere with the operating systems.

6. Follow Caltrain’s rules for access to and working in any rail operating territory.

F. Design Review Meetings

1. Preliminary Design Review
   a. Conduct a formal meeting for review of the Preliminary Design Submittal with the Engineer.
   b. The review shall be conducted no less than 21 days but no more than 45 days following an Engineer “approved” or “approved as noted” status of all the Preliminary Design submittals.
   c. Submit meeting minutes to the Engineer for concurrence no later than seven days after the Preliminary Design meeting.

2. Final Design Review
   a. Conduct a formal Final Design Submittal review meeting with the Engineer after the approval of all Preliminary Design submittals.
   b. The review meeting shall be conducted no less than 21 days but no more than 45 days following an Engineer “approved” or “approved as noted” status of the Final Design.
   c. Submit meeting minutes to the Engineer for concurrence no later than seven days after the Final Design meeting.

G. First Article Inspections

1. Perform First Article Inspection (FAI) for each subsystem and component that is custom built, custom assembled, or generally not accepted as a commercial off-the-shelf item or assembly. Examples of items for which an FAI should be performed include Communication Facilities and pre-wired Communications Cabinets.

2. The Engineer will determine the format in which the Contractor shall certify FAI performance based on the custom equipment or facility purchased. Examples include:
   a. Operational checklists of electrical system to include service outlets, lights, housekeeping alarms, and fire suppression.
   b. Operational checklists to show the functionality of custom made equipment which may include standby power systems, automatic signal switching, and alarm reporting.
   c. Cable run lists and equipment inventory records.
d. Cable (copper or fiber) test results.

3. The purpose of each FAI shall be to determine the following:

a. Based on inspection, measurement, and basic operation, whether the layout and mechanical aspects of the unit under inspection, e.g., Communications Facility, are consistent with Engineer approved drawings, requirements of these Specifications, and other design documentation. If not, the subject unit shall be re-assembled and the FAI repeated. Where maintainability, e.g., accessibility, safety, status indicators, power indicators and control, and exposure to power connector, are present in the unit, assessment of those maintainability aspects shall be included in the FAI.

b. Whether an acceptable level of workmanship that is consistent with approved workmanship standards and practices, is present in the initial copy of the unit under inspection. Where wiring, wiring connections, cabling, cable management, labels, tags or grounding connections are present in the unit under inspection, the workmanship standards, practices and procedures associated with the respective element shall be included as part of the FAI.

c. Whether an acceptable level of operating and maintenance safety is provided in the initial product submittal. If not, the unit shall be re-designed and re-assembled.

4. For each subsystem and component, the FAI shall be conducted at the earliest possible time in the manufacturing stage.

5. Notify the Engineer at least 21 days prior to each FAI.

6. The Engineer may request an FAI on any subsystem or component. For those subsystems or components where the Engineer requires a FAI:

a. Obtain the Engineer’s approval of the level of workmanship deemed to be acceptable.

b. The following, applicable to the subject subsystem or component, shall be available at the time of the FAI:

i. Engineer approved drawings and other design documentation

ii. Subsystem or Component Parts List

iii. Manufacturing and Quality Assurance Inspection Records

iv. Test Plan and Procedures

v. Tools and staff to make measurements
vi. Tools and staff to remove covers and perform limited disassembly

3.02 TESTING AND INSPECTION

A. This includes basic testing requirements. Where requirements for these activities are present elsewhere, the requirements specified in this Section shall be augmented by those additional requirements

B. General

1. The Contractor shall:
   a. Be responsible for successfully completing all tests required by these Specifications.
   b. Provide all test instruments and any other materials, equipment and personnel needed to perform the tests.
   c. Provide qualified personnel throughout all the required troubleshooting activities that may involve Communications System equipment.
   d. Be fully responsible for the replacement of all equipment damaged as a result of the tests, and shall bear all associated costs.
   e. Maintain comprehensive records of all tests.
   f. Notify the Engineer in writing, no less than 21 days prior to each test activity including factory testing.
   g. Provide test plans, procedures, records and reports for Engineer’s approval.

2. Engineer’s testing shall not be considered as a replacement for any Contractor required testing or manufacturer producing materials for the Contract required testing. The Engineer reserves the right to:
   a. Inspect test records at any time.
   b. Require the Contractor to perform additional testing, beyond that specified herein, of any equipment or material at any time to determine conformance with these Specifications.
   c. Observe the on-site testing at any time at the Engineers discretion and without prior notification of the Contractor.

C. Factory Testing

1. Factory testing shall be conducted for:
   a. All equipment provided for installed.
b. All components installed, integrated, and operated as a subsystem (to be tested as a subsystem).

2. Subsystem factory testing shall occur only after Final Design submittal package approval for that subsystem.

3. Factory testing for a subsystem shall be successfully completed prior to shipping any equipment for that subsystem.

4. If the equipment for a location is assembled at the factory, factory conduct testing for that equipment after all the racks and other subassemblies are integrated and rack interconnections are in place.

5. In order to show proper operation of all aspects, behavior, and characteristics, minimum requirements for equipment testing include the following:
   a. Manufacturer’s Recommended Testing
   b. Environmental Testing for Custom Equipment
   c. Power-up Testing
   d. Equipment burn-in of 72 hours, with concurrent operation of the equipment, for the full burn-in period
   e. After burn-in, comprehensive functional testing, including testing of all controls and indicators
   f. After burn-in, comprehensive diagnostic testing
   g. After burn-in, comprehensive performance testing
   h. After burn-in, comprehensive external interface testing, including verification of the following:
      i. Electrical Interface
      ii. Functional Interface
      iii. Mechanical Interface

6. Minimum requirements for subsystem testing include the following:
   a. Comprehensive Functional Testing
   b. Comprehensive Performance Testing
   c. Comprehensive External Interface Testing, including verification of the following:
      i. Electrical Interface
ii. Functional Interface

iii. Mechanical Interface

iv. Rack-to-rack Interconnects

D. Installation Inspection and Test

1. Pre-installation inspection shall include inspection for the following:
   a. Missing components and parts
   b. Correct serial numbers
   c. Damage to equipment

2. Inspect installed equipment, as a minimum, for the following:
   a. Conformance to standards, methods, and quality
   b. Correct location, positioning, mounting, and orientation
   c. Damage to equipment
   d. Correct and secure external connections
   e. Correct and secure routing of cable and wires
   f. Correct and secure internal connections
   g. Proper Grounding and Protection
   h. Verification of all configuration data and setting
   i. Correct labeling

E. Field Equipment and Subsystem Testing

1. Perform the following equipment field tests for all installed equipment. Additional field tests for each subsystem, listed in the subsequent paragraphs, shall not be construed to limit or otherwise relieve the Contractor of the responsibility for performing comprehensive field testing of the following:
   a. Basic equipment operation
   b. Functional and performance testing
   c. All external interfaces such as mechanical, electrical, and functional
   d. Operation in the presence of equipment and software failures
   e. Operation in the presence of power failure and restart
2. Subsystem testing shall include the following:
   a. Tests for proper local operation
   b. Tests to confirm the installed equipment or subsystem meets performance requirements
   c. Validation of all data used to configure or operate the subsystem

F. End-to-End Acceptance Testing

1. Refer to each Specification Section within Division 17, Station Communications.

G. Engineer’s Systems Integration Testing

1. Conduct System Integration Testing (SIT) in accordance with Engineer’s requirements.

2. Upon activation, interface, and integration of all required individual subsystems required for each line section cutover, provide SIT including technical support. Technical support shall include providing engineer, technician, and installation staff as well as tools, appliances, fixtures, expendable materials, supplies, and test equipment as needed to perform the SIT procedures or to develop and implement required corrective actions on the Contractor’s elements.

3. This testing shall involve the interaction of the Communications System operating with one or more other sub-systems and shall be required through System Final Acceptance.

4. SIT shall include testing of all communications subsystems added to, modified, or integrated as a result of work performed under this Contract and integrated or interfaced to existing systems and subsystems. Subsystem integration testing shall include:
   a. Rail Operations Control System (ROCS) and Passenger Information System indications and controls between intended field and control locations
   b. Station node integration
   c. Proper local and remote operation of Station PA and VMS messaging
   d. Proper operation of all voice circuits
   e. Proper transport and operation of TVM data and indications
H. Site Burn-In Testing

1. Where applicable, certain subsystems shall undergo a Site Burn-In Testing where the tested subsystem’s equipment and software shall maintain normal functioning in a fully operational mode during a predetermined approved period of time (i.e. 15-day, 31-day, etc.). The goal is to ensure the subsystem’s performance in accordance with the Contract requirements while avoiding pre-defined number of occurrences of major and minor subsystem malfunctions (caused by the issues in the Contractor design and/or implementation). Contractor shall identify such major and minor malfunctions in the corresponding subsystem Test Plan and Procedures, which shall be approved by the Engineer.

2. If during the burn-in period of time, the subsystem exceeds the approved number/types of such malfunctions, the burn-in testing shall be stopped and considered failed. The Contractor shall review the subsystem’s performance, submit for the Engineer’s approval the list of found issues with their explanation and proposed methods for rectifying the found issues. Upon correcting all such issues and as per approval by the Engineer, the burn-In testing shall restart again.

I. Inspections and Tests for Final Acceptance

1. Perform Final Acceptance inspections and tests for each portion of the Communications System following successful completion of System Integration Testing (SIT) for that portion. At this stage all the defects and other open items relevant to the system and identified up to that time, shall have been closed and system shall be ready for final inspection and acceptance test.

2. Inspection and tests as outlined in these Specifications shall demonstrate to the Engineer that, the System is operating in accordance with the requirements of these Specifications.

3. Perform "Complete Testing" for all equipment that exhibited faults during the SIT. "Complete Testing" shall be testing that is equivalent to the field and functional testing performed on the equipment when first installed are required by these Specifications and Engineer approved test procedures including submission of test results and test reports.

4. Perform "Complete Testing" for all equipment that was replaced under warranty. For all subsystems and equipment that have been changed after initial testing after installation, perform complete testing of such subsystem and equipment.

5. Verify the accuracy of the as-built documentation for each equipment location.

END OF SECTION
SECTION 17050
BASIC COMMUNICATIONS EQUIPMENT, MATERIALS, AND METHODS

PART 1 – GENERAL

1.01 DESCRIPTION

A. Section describes the detailed technical requirements for the products and miscellaneous components furnished, installed, and tested to complement the Station Communications subsystems.

1.02 GENERAL

A. The provisions of this Section apply to all Division 17, Station Communications, except as otherwise specified.

1.03 REFERENCE STANDARDS

A. American National Standards Institute (ANSI):


B. ASTM International (ASTM):

1. A123 Specification for Zinc (Hot-Dipped Galvanized) Coatings on Iron and Steel Products
2. A153 Specification for Zinc Coating (Hot-Dipped) on Iron and Steel Hardware
3. B3 Standard Specification for Soft or Annealed Copper Wire
4. D2447 Standard Specification for Polyethylene (PE) Plastic Pipe, Schedule 40 and 80, based on outside diameter
5. E84 Surface Burning Characteristics of Building Materials
7. F593 Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs

C. Consumer Electronics Association (CEA):

1. 310 Cabinets, Racks, Panels, and Associated Equipment.

D. California Building Code (CBC)

E. California Electric Code (CEC)

F. Electronic Industries Alliance (TIA/EIA):
1. 568-B.1-2 Commercial – Building Telecommunication Cabling Standard

2. 606 Administration Standard for the Commercial Telecommunications Infrastructure


G. International Building Code (IBC)

H. National Electrical Contractors Association (NECA):
   1. 1 Standard Practices for Good Workmanship in Electrical Construction

I. National Fire Protection Association (NFPA):
   1. 70 National Electrical Code (NEC)
   2. 130 Fixed Guideway Transit and Passenger Rail Systems
   3. 255 Standard Method of Test of Surface Burning Characteristics of Building Materials
   4. 703 Standard for Fire Retardant Impregnated Wood and Fire Retardant Coatings for Buildings

J. National Electrical Manufacturers Association (NEMA):
   1. 250 Enclosures for Electrical Equipment (1000 Volts Maximum)
   2. ICS-1 General Standards for Industrial Control and Systems
   3. ICS-4 Terminal Blocks
   4. ICS-6 Industrial Controls and Systems Enclosures
   5. FB1 Fittings, Cast Metal Boxes and Conduit Bodies for Conduit and Cable Assemblies
   6. LI1 Industrial Laminating Thermosetting Products
   7. VE1 Metallic Cable Tray Systems
   8. WC 7 Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
   9. WD 1 General Requirements for Wiring Devices

L. Underwriters Laboratories (UL):

1. 5 Surface Metal Raceways and Fittings
2. 6 Rigid Metal Conduit – Steel
3. 50 Enclosures for Electrical Equipment – Nonenvironmental Considerations
4. 50E Enclosures for Electrical Equipment – Environmental Considerations
5. 94 Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
6. 497 Standard for Safety Protectors for Paired Conductor Communications Circuits
7. 508 Industrial Control Equipment
8. 514A Metallic Outlet Boxes
9. 514B Conduits, Tubing and Cable Fittings
10. 651 Schedule 40 and 80 Rigid PVC Conduit and Fittings
11. 969 Marking and Labeling Systems
12. 1059 Terminal Blocks

M. Uniform Building Code (UBC)

1.04 SUBMITTALS

A. Submit Installation Work Plan including the following items:

1. Equipment layout, plan and elevation views
2. Conduit installation from Communications Equipment Room (CER) and field Distribution Cabinets (DC)
3. Wiring diagrams from CER to DC including all tagging identifiers

B. Submit a complete bill of materials (BOM) and the corresponding data sheets for all equipment and accessories, which the Contractor intends to use for the project (as a part of the Preliminary and Final Design).

C. Product Samples: Submit and demonstrate product samples when requested by the Engineer or when required.
D. Calculations and Certifications:

1. Calculations as listed in the Preliminary Design and Final Design. Refer to Section 17000, Basic Communications Technical Requirements.

2. Copy of ISO certification for all proposed manufacturers.

E. Software, Schedules, and Lists:

1. Submit dedicated cable management software for Owner’s use.

2. Submit typed (printed) wiring interconnect schedules and schedule of conduits, wires and cables as specified to be produced by required dedicated cable-management software.

3. Submit complete typed or printed list of cable, wire, and conduit identification tags for approval.

F. Manufacturer Qualifications: Submit qualifications for any manufacturer differing from those specified herein and obtain Engineer’s approval. Acceptability of the manufacturer shall be based on the manufacturer’s experience, qualifications, and certifications (i.e. ISO-9001); equipment reliability; compliance with specified standards; and full compatibility with Caltrain’s existing systems.

G. As-Built Documentation: Submit complete As-Built documentation and drawings, as specified in Section 17000, Basic Communications Technical Requirements, for all Miscellaneous Components and Products.

1.05 QUALITY ASSURANCE

A. Applicable Standards and Code:

1. All equipment and methods shall comply with the applicable standards listed under Reference Standards.

B. Material and Workmanship Requirements:

1. All equipment provided under this Section shall be UL listed.

2. All products specified herein shall be subject to Engineer’s approval based on the Contractor’s ability to demonstrate adherence to the specified requirement and approval of the manufacturer’s quality process.

3. Use no discontinued product models, refurbished equipment, or products scheduled for end-of-life, end-of-sale, or end-of-service within one calendar year of the installation date.

4. All grounding shall be in accordance with NEC standards, and as specified for the Work except as modified herein. Ground each piece of equipment in accordance with the recommendations of the manufacturer.
PART 2 – PRODUCTS

2.01 CIRCUIT BREAKERS, FUSES, AND FUSE CLIPS

A. Capacity:
   1. Fuses and circuit breakers shall be suitable for protection of the equipment and cabling connected.

B. Fuse Type:
   1. Fuses shall be non-renewable time lag fusion type.
   2. Protective resistance shall be used in branch circuits.

C. Fuse Clips:
   1. Positive contact pressure shall be applied to the fuses to ensure electrical continuity.

2.02 TAGGING

A. Cables, Wires and Conduits:
   1. Install cable identification tags at both ends of each cable, including wires, where they terminate on terminals, punch-down blocks, and connectors. Communications cable identifiers shall comply with standard TIA/EIA-606. This includes all electrical power wires and cable for communication facilities and equipment.
   2. Tag cables at the entrance and the exit of each manhole, pull-box, hand-hole, junction box, splice-box, cable trough, or fiber-slack enclosure.
   3. Tag conduits at the entrance and the exit of each manhole, pull-box, hand-hole, junction box, splice-box, cable trough, or fiber-slack enclosure.
   4. Use water-resistant identification tags with lamination over its designation for all conduits, cables, and wires. Permanently typed lettering shall be used.
   5. Use sleeve type non-metal tags where cable diameter permits.
   6. Use flat plastic tags for smaller cables (and all conduits): Two holes in the tag shall be provided for attachment with a dielectric tie.
   7. Furnish, use, and then submit to the Engineer a dedicated cable-management software, including software license, to provide Class 4 administration of the communication cables per standard TIA/EIA-606. Software shall be able to properly operate on Windows 2000, or latest revision of, operating system and be able to produce the following types of schedules:
a. Typed wiring interconnect schedule for all external and internal wires and cables listing wire (cable) tag identification, To and From locations, To and From termination terminals, wire (cable) size and type, all conduit (raceway) tag identifications that wire (cable) is installed, all raceway size and type, and manhole (pull-boxes) that cable or wire is installed through.

b. Typed wiring interconnect schedule for each location and each facility for the entire project.

c. Typed schedule of conduits, wires, or cables to include quantity of each.

8. Cable, wire, and conduit identification tags: The tags shall follow the following sample format. Each cable, wire, and conduit shall have its own unique identification tag. If a wire is not terminated, then tag it “spare-1”, “spare-2”, “spare-3”, and so forth.

a. Sample tag scheme for External Cable, HIL-CER-FDP / BAS-CER-FDP-FS12-01; with:
   i. HIL represents originating location “from” (Hillsdale)
   ii. CER represents originating facility type (Communications Equipment Room)
   iii. FDP represents originating termination cabinet/panel (Fiber Distribution Panel)
   iv. / represents “to”
   v. BAS represents ending location (Bayshore)
   vi. CER represents ending facility type (Communications Equipment Room)
   vii. FDP represents ending termination cabinet/panel
   viii. FS12 represents cable type (Fiber Single-mode 12 strand)
   ix. 01 represents cable number (01-99)

b. Sample tag scheme for Station Distribution Cable: HIL-CER-FDP / DC1-FS02-01; with:
   i. HIL represents Location “from”
   ii. CER represents facility type
   iii. FDP represents originating cabinet/panel
   iv. / represents “to”
v. DC1 represents ending distribution cabinet, panel, or equipment

vi. FS02 represents cable type (Fiber Single-mode 2 strand)

vii. 01 represents cable number (01-99)

c. Sample tag Scheme for Internal Wires within the same CER or DC, FS01-01-FDP-SL4-14 / RTU-TB5-11; with:

i. FS01 represents cable type (Fiber Single-mode 1 strand patch cord)

ii. 01 represents cable number (01-99)

iii. FDP represents originating cabinet/panel

iv. SL4-14 represents originating demarcation panel/card slot and port number

v. / represents “to”

vi. RTU represents ending cabinet, panel, or equipment

vii. TB5-11 represents ending termination block and termination terminal, jack, or port number

d. Sample tag Scheme for External Conduits, HIL-CER / BAS-CER-PCO-01-3; with:

i. HIL represents originating location area (Hillsdale)

ii. CER represents originating facility type

iii. / represents “to”

iv. BAS represents ending location area (Bayshore)

v. CER represents ending facility type

vi. PCO represents Pathway, such as “conduit”

vii. 01 represents conduit one (01-99)

viii. 3 inch represents 3 inch diameter conduit

e. Sample tag Scheme for Internal Conduits, CER-FDP / PB01-PCO-01-0.75; with:

i. CER represents originating facility type “from”

ii. FDP represents originating cabinet/panel
i.  / represents “to”  

ii.  PB01 represents ending pull-box, cabinet or equipment  

iii.  PCO represents Pathway, such as “conduit”  

iv.  01 represents conduit one (01-99)  

v.  0.75 inch represents 0.75 inch diameter conduit  

B. Equipment:

1. Label all terminal blocks, card cages, circuit cards, punch-down blocks, and jack fields. Communications equipment identifiers shall comply with TIA/EIA-606.  

2. Use permanent lettering scheme.  

3. Attach labels with a non-drying adhesive.  

4. Show the correct communication equipment identifier on every respective equipment drawing and schematic.

2.03 PUNCHDOWN BLOCKS

A. Type:

1. Blocks shall be IDC-Type 50 pair punch-down blocks. Blocks shall be configured with two columns of 25 pairs of two termination clips. Clips shall accept No. 20 AWG - No. 26 AWG insulated wire, and No. 18 AWG - No. 19 AWG bare wire. Blocks used for data cable termination shall be rated at or higher than the rating of the cable being terminated.  

2. Clips shall be pre-wired to an Amphenol type RJ21X connector socket or equal.  

3. Blocks shall be equipped with a base, standoff bracket, cover, and bridging clips.  

B. Base:

1. The base shall be impact resistant plastic.  

2. Provide molded fanning strips on each side of the split blocks.  

3. Apply permanent numbering to the fanning strips.  

4. Provide a standoff of two inches from the mounting surface.  

5. Provide a removable cover with circuit designations permanently applied.  

6. Provide connector retention screws.
2.04 TWENTY-FIVE PAIR CONNECTORS

A. Type:
   1. Connectors shall be Amphenol-type RJ21X, or equal, with a self-extinguishing thermoplastic housing.
   2. A slide on cover shall protect the connector contacts.
   3. Provide retention screws.
   4. Connectors shall be non-reversible and shall be compatible in design and type (male/female) with the associated receptacles.

B. Connector Contacts:
   1. Provide two (2) rows of 25 contacts.
   2. Contacts shall be insulation displacement type, designed to accept No. 22 and No. 24 AWG wire.

2.05 PROTECTED ENTRANCE TERMINALS

A. Design:
   1. Use protected entrance terminals at the input for all signal/communications circuits using metal cable and entering/exiting the facility (e.g. Communications Facilities and DC). Use connectorized protected entrance terminals in all applications unless specifically stated otherwise in this Section or on the Contract Drawings.
   2. Protected entrance terminals shall have a field splice line side connection stub pre-wired to three element (five pin) protector sockets. Connect the equipment side of the protectors via RJ21 connectors.
   3. Blocks shall be 110 Cat 5e/6 rated or Engineer approved equal.
   4. Protected entrance terminals shall include an integral splice chamber.
   5. Provide protected entrance terminals in 25, 50, and 100 pair sizes and fully populated with protector modules as per the application shown on the approved drawings.

B. Protector Sockets: Protector Sockets shall be UL standard five pin sockets, with two-position (normal and detent) design. In the detent position, the protector shall be retained, the line side shall be disconnected, and the equipment side shall be protected. When fully inserted, the line and equipment side having the tip and ring pair shall be protected.
2.06 MULTI-PAIR PROTECTED TERMINAL BLOCKS

A. Design:

1. Utilize multi-pair protected terminal blocks for applications requiring non-connectorized 25 pair or less terminal blocks, as specified on the Contract Drawings.

2. Types and pair counts for terminal blocks shall be as shown on the approved drawings.

3. Terminal blocks shall consist of pairs of brass binding posts imbedded in high impact plastic potted with a high dielectric polyurethane compound.

4. Pre-wire binding posts to two element protector sockets. Wire the ground of all protector sockets to a common ground terminal.

5. Equip binding posts with two brass nuts and washers. Size binding posts to accept up to two No. 14 AWG conductors.

2.07 PROTECTOR MODULES

A. Three Element (5-Pin) Protectors: Protectors shall be solid-state modules with fuses or heat coils specifically designed for lightning protection.

1. Modules shall plug into 5-pin protected entrance terminal sockets.

2. Each module shall protect both halves of a pair.

3. Protector modules shall be UL 497 listed for primary protection.

4. Modules shall have 2 ns to 5 ns response time.

5. Modules shall protect for voltages over 230 Vdc.

6. Modules shall protect for currents over 80 A.

B. Two Element Protectors: Protectors shall be solid-state modules with fuses or heat coils specifically designed for lightning protection.

1. Modules shall plug or screw into protected terminal blocks.

2. Protector modules shall be UL 497 listed for Primary protection.

3. Modules shall have 2 ns to 5 ns response time.

4. Modules shall protect for voltages over 230 Vdc.

5. Modules shall protect for currents over 80 A.
2.08 MAIN DISTRIBUTION FRAMES

A. Communications Facilities Main Distribution Frame (MDF): Each MDF shall consist of the following minimum equipment:

1. A wall mounted 4 feet by 8 feet, 3/4-inch marine grade sanded and smooth surface plywood backboard for mounting equipment.

2. A minimum of two 100-pair connectorized protected entrance terminals (PET) fully equipped with protector modules for each active and inactive or unused circuit, as described in entitled Protected Entrance Terminals and Multi-Pair Protected Terminal Blocks herein. PET block shall be contained within a separate enclosure mounted on the MDF backboard. Enclosure shall have a fully removable cover in order to provide access to protected terminal blocks. (Mount on plywood backboard)

3. A minimum of eight 110 Type CAT 5e/6 50-pair connectorized punch-down blocks (as described in Articles entitled Punchdown Blocks herein) utilizing 25 pair connectors per Article entitled Twenty-Five Pair Connectors as cross-connects. (Mount on plywood backboard)

4. Provide binding post type terminal blocks as described in Article entitled Multi-Pair Protected Terminal Blocks herein and as shown on Contract Drawings. (Mount on plywood backboard)

B. Outdoor Distribution Cabinet (DC) Local Distribution Frame (LDF):

1. Each Outdoor DC or similar application shall consist of the following minimum equipment mounted to the Lexan panel mounted on the interior side panel of the DC:
   a. One duplex 120Vdc UPS receptacle and back-box. Receptacles will be NEMA L5-30R (twist lock).
   b. One duplex 120Vdc general purpose receptacle and back-box.
   c. Multi-pair protected terminal blocks designed for a minimum of 24-pairs of PA speaker and microphone connections. Such protection blocks shall be specifically designed for PA applications.
   d. Protection blocks for outdoor Category 5e/6 for Category 6 rated data wiring entering the facility or the cabinet.
   e. Protection blocks for any other outside plant cabling containing conductive (metal) elements. Such protection blocks shall be designed specifically for use with the intended application.
2.09 CABLE TRAYS

A. Cable trays shall be of open ladder type, aluminum, or other suitable material commercially available and providing support spacing and strength of material characteristics equal to or greater than the aluminum.

B. The aluminum ladder type cable tray shall meet the following requirements:
   1. Ladder rung spacing shall be approximately 6 inches.
   2. Side stringer section shall be a minimum of 0.094 inches.
   3. Top and bottom flange section shall each be a minimum of 2 inches.
   4. Flange width shall be approximately 0.75 inches.
   5. Height of rail shall be approximately 3.375 inches.
   6. Rung thickness shall be a minimum of 0.062 inches.
   7. Rung bottom width shall be approximately 2.20 inches.
   8. Rung top width shall be approximately 0.75 inches.
   9. Plastic tray insert barrier to separate power and signal cables.

C. Each cable tray shall be designed and fabricated with sufficient capacity to provide 50 percent of the cross-sectional area as free air space after the full number of cables and wires are installed. Sufficient overhead space must be available after installation to permit wires and cables to be inspected.

D. Where practical, the tray shall be constructed in straight sections joined with Engineer approved couplers. Electrical continuity of the tray shall be maintained across sections by bonding straps.

E. Using the manufacturer’s standard, the tray shall be laid out using a minimum number of sections, but providing maximum continuous runs without gaps.

F. All fittings, supports, and accessories shall be provided in accordance with the manufacturer’s recommendations.

G. Insofar as practical, cable trays shall be supported by cantilever type brackets in order that the cables can be laid into the tray without pulling.

H. Where the width of the cable tray or the loading of cables is such that cantilever supports are impractical, other Engineer approved suspension methods may be used, but such application must be kept to a minimum.

I. At least three supports shall be provided for each length of tray. Supports shall be evenly spaced insofar as possible; in no case shall the spacing between adjacent supports exceed five (5) feet.
J. To prevent damage to cables, no metal edges of any description shall protrude and no sharp corners shall exist in the completed layout.

K. Fiberglass support arms, where required to insulate the cable tray from the equipment racks, shall be flame retardant, reinforced polyester laminate Class "B" 130 degrees Celsius electrical sheet, meeting NEMA GPO-2 requirements specified in NEMA L11.

2.10 OUTDOOR EQUIPMENT CABINETS

A. Outdoor equipment cabinets shall be floor mounted encasing an 19 inch EIA aluminum equipment mounting rack. Cabinets shall have an overall height of 48 inches, unless otherwise indicated on the Contract Drawings. The cabinets shall have CEA-310 standard 1 3/4 inches spaced single side drilled, tapped mounting holes.

B. The cabinet base shall have a minimum depth of 30 inches. Cabinets shall have continuously welded seams and gasket front and rear doors.

C. Obtain the approval of the Engineer to finish the outside of each cabinet. All cabinets shall be painted identically.

D. Cabinets shall be equipped with screw clamp connection for grounding.

E. Cabinets shall be grounded to the Chassis Grounding Buss-bar (CGB). Each cabinet rack shall have separate ‘signal/communications’ and ‘power’ grounding bars, which are connected to the Chassis Grounding Buss-bar (CGB) independently from each other and from other racks (where applicable).

F. Cabinet shelves (both fixed and slide-out type) shall be provided as shown in the Contract Drawings.

G. Cabinets shall be equipped with ac power strip, ground bus-bars, horizontal and vertical cable management, and other non-electronic type components as shown on the Contract Drawings.

H. Cabinets shall be equipped with locking front and rear steel doors.

I. Cabinets shall be equipped with louvered side panels.

J. Cabinet design, furnish, and installation shall comply with Section 17160, Outdoor Communications Cabinets.

2.11 INDOOR COMMUNICATIONS CABINETS

A. Design:

1. Where communication equipment cannot be housed in open equipment racks within controlled spaces dedicated for communications only, locked cabinets shall be used and designed for EMI shielding with the following features:

   a. Continuously Welded Seams
b. Gasket Front and Rear doors  
c. Screened Ventilation Openings  
d. Tested per Mil Std. 285

2. Cabinet construction and materials shall be as follows:
   a. 14 gauge or heavier steel frame. 
   b. 16 gauge or heavier panels. 
   c. 16 gauge or heavier struts. 
   d. 16 gauge mounting rails with CEA-310 rack mount standard spaced holes for equipment mounting widths of 19 inches and 23 inches. 
   e. Both front and rear doors shall be removable. 
   f. Locking front and rear removable doors shall be provided. All keys shall be alike and master keys shall be provided to the Engineer. 
   g. Communications House cabinets shall be installed on insulating sills as shown on Contract Drawings. 
   h. Cabinet shelves (both fixed and slide-out type) shall be provided as shown in the Contract Drawings. 
   i. Cabinets shall be equipped with AC power strip, power and communications ground bus-bars, horizontal and vertical cable management, and other non-electronic type components as shown on the Contract Drawings. 
   j. Cabinets shall be equipped with louvered top and side panels. 

3. Finish:
   a. Obtain the approval of the Engineer to finish the outside of each cabinet. All cabinets shall be painted identically. 
   b. Finish inside of each cabinet in flat white enamel. 
   c. Racks or cabinets shall be grounded to the Main Grounding Buss-bar (MGB) as shown in the Contract Drawings. 

2.12 MULTI-PAIR DISCONNECT MODULE TERMINAL BLOCKS

A. Design: Multi-pair disconnect module terminal blocks shall be 110 Type CAT 6 Rated or Engineer approved equal. Terminal blocks shall provide normally closed two-piece (line side and equipment side) insulation displacement contacts in 8 to
50 pair modules, as per the application shown on the Contract Drawings. Disconnection of the line side from the equipment side shall be by insertion of a disconnect plug.

B. Performance:

1. Contacts shall accept No. 20 AWG through No. 26 AWG insulated conductors.
2. Contact resistance shall be less than $1 \times 10^{-3}$ ohms.
3. Insulation resistance shall be greater than $50 \times 10^{12}$ ohms.
4. Wire retention force shall be greater than or equal to 75 percent of wire breaking force.

PART 3 - EXECUTION

3.01 INSTALLATION

A. General: All parts of the specifications pertaining to miscellaneous components and products shall be installed as specified in this specification and in accordance with the Contract Drawings.

B. Twenty-Five Pair Connectors:

1. Cable Attachment Tool: Twenty-five pair connectors that are attached to cables in the field shall be made-tip utilizing an Engineer approved connector attachment.

2. Testing: Test twenty-five pair connectors that are attached in the field, utilizing an Engineer approved tester that detects opens, shorts and crosses. Also, verify color code.

C. Terminal Blocks:

1. Make connections to terminal blocks in accordance with the Engineer approved connection details. Utilize twisted pair jumper wire for cross-connections.

2. Neatly bundle all wiring on terminal blocks and restrain to prevent tracing wires by pulling.

3. Utilize tags and labels to identify the terminal block designation and the pair number terminated on each terminal.

4. For protected terminal blocks, ground protected terminal blocks with No. 6 AWG minimum ground wire to the cabinet communications ground.

5. Test all protector modules prior to installation on terminal blocks.
D. Main Distribution Frames:

1. Backboard Mounting in Communications Facilities.
   a. Secure plywood backboard to the wall in such a manner that it will adequately support the weight of all equipment and cables that are attached to it. Cable termination and management devices shall be provided and subject to the Engineer’s approval.
   b. Prime and apply fire retardant paint to the backboard to all exposed sides prior to installation of any equipment.
   c. Floor conduit stub-ups shall be extended to 2 feet above finished floor as shown on the Contract Drawing.

2. MDF and miscellaneous equipment mounting in Distribution Cabinets (DC) shall be as shown on Contract Drawings.

3. Wiring:
   a. Wire each MDF in accordance with an approved cross-connect and wire termination plan.
   b. Utilize tags and labels to identify the cross-connect module designation and the pair number terminated on each quick-clip. All tag and label designations shall be transferred to the as-built drawings. Method of tagging and labeling shall be in accordance with Article entitled Tagging herein.
   c. Neatly bundle cables and cross-connect wiring and restrained using Velcro ties.
   d. Individually ground each distribution frame, equipment rack or cabinet, protected terminal block, or cable tray section, to the Communications Equipment Room (CER) Main Grounding Bus-bar (MGB) with No. 6 AWG ground wire and lugs as shown on the Contract Drawings.

E. Cable Tray:

1. Attachment: Each cable tray section shall be attached to the Communications Facility ceiling utilizing expansion fasteners required for the ceiling material. Fasteners shall be rated for a pull-out load equal to at least 150 percent of the maximum rated load for each cable tray section.

2. Cable trays shall be attached horizontally to 19” racks to provide neat and secure mounting of equipment cables.

3. Grounding: Cable tray shall be grounded to the Communications Facility MGB utilizing No. 6 AWG minimum ground wire. Electrical continuity of the cable tray shall be maintained between sections utilizing No. 6 AWG
minimum ground wire and attachment hardware, as recommended by the manufacturer.

4. Installation of Cable:

a. Cables shall be laid into the tray, rather than pulled, wherever possible, so as to eliminate twisting. Cables shall be attached to the tray utilizing dielectric ties so as to maintain straight runs and adequate separation of cables. Cables carrying ac and dc power shall be separated from audio and data cables to the maximum extent possible.

b. Fiber optic distribution cables will be encased in 1 inch inner-duct and attached to the tray utilizing dielectric ties. Fiber and inner-duct shall be separated from copper cables. Inner-duct will run the full length of the cable tray to the Fiber Distribution Panel (FDP) opening.

c. Fiber Optic patch cables shall not be installed with bend diameters less than those specified by the vendor.

F. Internal Wiring and Cabling:

1. Internal wiring shall be installed in wiring harnesses or cable trays.

2. Wire and cable shall be secured within ducts or open wire ways to prevent chafing movement.

3. Strain relief shall be provided where needed.

4. Wire or cable splices will not be permitted.

5. All wires and cables shall be fully protected against any contact with any surface other than that designed specifically to support or protect them.

6. Wires and cables shall be laid in place with sufficient slack at the bends so that wires and cables will clear the inside bend surface of the wire way, thereby preventing the insulation from being crushed.

7. All wire and cable shall be free of kinks and insulation damage. Wire installation shall not be subject to accumulations of moisture or foreign matter.

8. Wire and cable dress shall allow for sufficient slack to provide for shock and vibration induced movements, movement of sliding racks, equipment shifting, alignment, cover removal, and component replacement.

9. All wire and cable bends shall conform to the manufacturer recommended wire/cable specific minimum bend radius. All wire and cabling harness and dress arrangements shall also account for this requirement.
10. Wiring and cabling dress in harness arrangements shall be tied with a high strength approved Velcro type wire-tie.

11. For rack wiring, utilize rack’s cable management hardware for routing and securing of the wires and cables.

12. All 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.

END OF SECTION
SECTION 17060

GROUNDING OF COMMUNICATIONS EQUIPMENT

PART 1 - GENERAL

1.01 DESCRIPTION

A. Section includes requirements for grounding and bonding for communications systems.

1.02 REFERENCE STANDARDS

A. American National Standards Institute (ANSI):

1. J-STD-607-A Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications

B. American Society for Testing and Materials (ASTM International):

1. B187 Specification for Copper, Bus Bar, Rod, and Shapes and General Purpose Rod, Bar and Shapes
2. B3 Specification for Soft or Annealed Copper Wire
3. B8 Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
4. B8 Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
6. D5 Test Method for Penetration of Bituminous Materials
7. D149 Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
8. D257 Test Methods for DC Resistance or Conductance of Insulating Materials

C. Institute of Electrical & Electronics Engineers (IEEE):

1. 80/81 Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.
2. 142 Recommended Practice for Grounding of Industrial and Commercial Power Systems
3. 1100 Recommended Practice for Power Grounding Sensitive Electronic Equipment

D. Lightning Protection Institute (LPI):
   1. 175 Standard of Practice
   2. 176 Standard of Materials

E. National Fire Protection Association (NFPA):
   1. 70 National Electrical Code (NEC)
   2. 130 Fixed Guideway Transit and Passenger Rail Systems
   3. 780 Standard for the Installation of Lighting Protection Systems

F. National Electrical Safety Code (NESC)

G. California Electric Code (CEC):
   1. Title 24 California Electrical Code Part 3

D. Underwriters Laboratories (UL):
   1. 467 Safety Grounding and Bonding Equipment

1.03 SUBMITTALS

A. Refer to Section 17000, Basic Communications Technical Requirements, for related and additional submittal requirements.

B. Preliminary Design Technical Requirements: Include the following information as part of the Preliminary Design for the Grounding and Bonding of communications systems

   1. Manufacturer's catalog data for all proposed materials with installation recommendations. Product data sheets shall include, but not limited to, the following:

      a. Ground conductors
      b. Connectors, bushings, and fittings
      c. Exothermic welding process, materials, and molds
      d. Ground rods
      e. Ground test stations and Bus Bars
      f. Ground Well Boxes (where applicable)
      g. Lightning/Surge protection and arrester equipment
2. Master Drawing Index

3. Drawings showing grounding arrangement for communications facility and cabinets, including locations of ground rods, cables and connectors.

4. Drawings showing details of ground connections, ground test stations, ground risers, terminations and access points, including details of connections of panels and their end connections to the Main Grounding Bus-bars (MGB); and typical grounding details showing electrical systems, equipment, metallic conduit/cable tray and non-current carrying conductive entity grounding and bonding connection.

5. Drawing showing mounting details of all ground bus-bars.

6. Grounding calculations to demonstrate the installation meets the Specification requirement of the 3 ohms.

C. Final Design Technical Requirements: Shall include the following information as part of the Final Design submittal package for the Grounding and Bonding of communications systems.

1. Updated Preliminary Design information. All drawings, calculations and design information shall reflect a final design.

2. Final installation details.

D. Installation Work Plans: Shall include the following installation documents for each site with scheduled installation activity in accordance with these Specifications.

1. Locations of ground rods, connectors, cables, and details of connections, terminations and access points.

2. Manufacturer’s installation recommendations.

E. Certifications: Certified test reports verifying that ground resistance of each ground grid when installed and each ground bus when connected to the ground grid does not exceed specified values.

F. Product Samples: Submit and demonstrate product samples when requested by the Engineer.

G. Test Plan and Procedures: Submit procedures and equipment for testing resistances and electrical continuity for each location.

H. Test Records: Submit test records including Test Records and Results for Engineer review no later than one week after the completion of each test.

I. As-Built Documentation: Refer to Section 17000, General Communications Technical Requirements, for requirements. Include complete As-Built documentation and drawings for the Grounding and Bonding of all communications systems completed.
1.04 QUALITY ASSURANCE

A. Design, fabrication, inspection, installation and testing shall comply with all applicable Standards and Codes as listed under Reference Standards.

B. Material and Workmanship Requirements:
   1. All equipment and material provided under this Section shall be UL listed.
   2. All grounding shall be in accordance with local standards, except as modified herein. Each piece of equipment shall be grounded in accordance with the recommendations of the manufacturer.
   3. Use no discontinued product models, refurbished equipment, products at their end-of-life, end-of-sale, or end-of-service.

C. All products specified herein shall be subject to the Engineer approval based on whether Contractor demonstrates adherence to the specified requirement and Engineer approval of the manufacturer’s quality process.

PART 2 - PRODUCTS

2.01 GENERAL DESIGN REQUIREMENTS

A. Grounding/bonding systems shall provide for the following three primary functions:
   1. Personnel safety
   2. Equipment and building protection
   3. Electrical noise reduction

B. Subsystem: Facilities Lightning Protection
   1. A lightning/surge protection system shall be provided for all communications and wayside facilities including Communications Facilities, outdoor Public Address/Visual Message System (PA/VMS) equipment, Ticket Vending Machines (TVMs), Closed Circuit Television (CCTVs), Card Interface Devices (CIDs) or Clipper, Communications Equipment Rooms (CERs) and Distribution Cabinets (DCs). The lightning protection system shall be in accordance with the requirements of ANSI/NFPA 780, Lightning Protection Code. The lightning protection system shall consist of multiple facility/equipment air (lightning) terminals, lightning/surge arrestors, down conductors, equalizing conductors, and ground terminals. This hardware shall provided for the Communications Facility for the purposes of intercepting, diverting, and dissipating direct lightning strikes or adjacent power lines faults, electrical ground faults, short circuits, and transients.
   2. The spacing and interconnection of the lightning protection system with the communications system grounds shall be in accordance with ANSI/NFPA 780. Communications grounds shall be bonded to the
lightning protection system grounding within 12 feet of the base of the building. Communications conductors shall not be routed closer than 6 feet from any lightning protection system conductors. The grounding and bonding design scheme shall include an assessment for Lightning Protection System and bonding requirements as part of the Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC) Control and Test Plan.

3. Lightning protection systems and installers shall be certified to LPI-175 and LPI-176 standards.

2.02 GROUND RODS

A. Ground rods shall be medium carbon steel core, copper-clad by the molten weld casting process, of the non-rusting type as manufactured by Copperweld Corporation, or approved equal. The rod shall be at least 1 inch in diameter by 10 feet long, UL listed. Where the design calculations show as required, rod installations of more than 10 feet length shall utilize sectional type ground rods joined by threaded copper alloy couplings.

B. Ground rod clamps shall be made of a cast bronze clamp body with non-ferrous setscrews as manufactured by Copperweld Corporation or an Engineer approved equal.

2.03 EXOTHERMIC WELDS

A. 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 39,000 pounds per square inch (psi).

B. Coating Materials for Welded Connections: Use black, rubber based compound coating materials, which are soft, permanently pliable, moldable, and unbacked, not less than 1/8 inch thick, with properties as follows:

1. Solids: 100 percent
2. Density: 12.0 pounds per gallon minimum
3. Penetration: 90-130 ASTM D5
4. Water Absorption: 0.10 percent maximum ASTM D570
5. Dielectric Strength: 500 volts/mil ASTM D149
6. Volume Resistivity: 2,000 megohms-inches ASTM D257 5,000 megohms-cm ASTM D257
7. Service Temperature: -10 degrees F to +160 degrees F
8. Chemical Resistance: Melting point, none; flammability, slow burning (ASTM C653); resists alcohol, water, aqueous hydrochloride and sodium
hydroxide; dissolved by carbon tetrachloride, naphtha gasoline, mineral, spirits, and benzene.

C. Highly cohesive and adheres strongly to metals and adhesive concrete and to itself.

D. Compression or mechanical type grounding connections are not equal to exothermic welded connections for applications in concealed, underground, wet or damp location, and are not permitted.

2.04 GROUND GRID CONDUCTORS

A. No. 2 AWG bare solid tinned copper conductor, or as shown on Contract Drawings.

2.05 GROUND ELECTRODE CONDUCTORS

A. Insulated stranded copper conductor, as shown on Contract Drawings, in accordance with these Specification, for single-conductor cable, 600 volts.

B. Size unless otherwise shown:

1. When connecting ground grid to Telecommunications Main Grounding Bus-bars (MGB) at Communications Facilities, insulated No. 2 AWG will be used. Use green color insulation for such conductors.

2. When connecting ground grid to Telecommunications Grounding Bus-bars at cabinets, insulated No. 6 AWG will be used. Use green color insulation for such conductors.

3. For other grounding electrode conductors: In accordance with NEC Table 250-94.

C. Equipment Grounding Conductors

1. Size in accordance with NEC article 250-95, unless otherwise shown on Contract Drawings.

2. Equipment grounding insulated conductor: No. 6 AWG single conductor stranded copper as specified in these Specifications. Use green color insulation for such conductors.

D. Static Dissipative Tile: Static Dissipative Tile (SDT) shall be used in Communications Facilities to prevent equipment damage due to static discharge. Ground SDT ground strips to the MGB in accordance with the manufacturer’s instructions using a minimum of No. 12 AWG copper wire.

2.06 TELECOMMUNICATIONS MAIN GROUNDING BUSBARS

A. Telecommunications Main Grounding Bus-bars (MGB), located in Communications Facilities shall be as follows:

1. ASTM B187, 98 percent conductivity copper.
2. Predrilled electro-tin plated copper bus-bar provided with standard NEMA bolt-hole sizing and spacing for the type of connectors to be used.

3. Sized in accordance with the immediate requirements of the application and with consideration for future growth (provide approximately 50 percent spare holes).

4. Minimum dimensions shall be ¼ inch thick x 4 inches wide and variable in length.

B. Communications Ground Buss-bar (CGB) located in communication cabinets shall be as follows:

1. ASTM B187, 98 percent conductivity copper.

2. Predrilled electro-tin plated copper bus-bar provided with standard NEMA bolt-hole sizing and spacing for the type of connectors to be used.

3. Sized in accordance with the immediate requirements of the application and with consideration for future growth (provide approximately 50 percent spare holes).

4. Minimum dimensions shall be ¼ inch thick x 2 inches wide and variable in length, or as shown on site specific drawings.

2.07 TERMINAL LUGS

A. Lugs shall be suitable for attaching a ground conductor to equipment or metallic surfaces, and shall be NEMA 2-hole, compression type chosen as follows:

1. For No. 4/0 AWG and smaller conductors, use copper compression terminal lugs.

2. For No. 250 MCM and larger, use long barrel, copper, double-compression terminal lugs.

2.08 GROUND CONNECTOR

A. Mechanical connectors shall be used for grounding connections above ground in dry locations only, and for attachments to equipment, boxes, or finished electrical devices

B. O-Z Gedney, Type KG or Engineer approved equal.

C. Two-piece, designed for connecting grounding conductor to bus bar.

D. Copper alloy body and silicon bronze bolt, nut and washer with interlocking clamp.

E. Exothermic weld: Size and type per manufacturer’s recommendations. See also subpart 2.03 above.
2.09 JUMPERS
A. Jumpers shall be insulated copper braided or leaf-type flexible jumper, size as required.

2.10 BUSBAR INSULATORS
A. Fibrous glass reinforced polyester insulator with ½ inch diameter by 2 inches length, threaded holes at both ends for MGB and CGB installation.

2.11 COAL TAR EPOXY
A. Polyamide cured coal tar epoxy, Dupont Coriar 823 CTE, Koppers Company No. 300M, PPG Industries 97-640 or 97-641 or Engineer approved equal, applied to a dry film thickness of 15 mils, per coat.
B. Coal tar epoxy coating products shall have the following minimum properties:
   1. Minimum volume resistivity of 1010 ohm-centimeters.
   2. Thickness as recommended by the manufacturer for the specified system but not less than 15 mils.
   3. Provide a chemical or mechanical bond to the metal. Pressure sensitive or nonbonding systems are not acceptable.
   4. Mechanical characteristics capable of withstanding reasonable abuse during handling and installation and earth stresses after installation for the design life of the system.

2.12 EPOXY RESIN ENCAPSULATION
A. Two-component epoxy resin type with plastic snap mold, as manufactured by Duriron Company, 3-M Company or Engineer approved equal.

2.13 COMMUNICATIONS FACILITY ROOM HALO GROUND RING
A. The halo shall be No. 4 AWG bare stranded copper conductor. It shall encircle the perimeter of the interior walls of the Communications Facility at a uniform height of 3 inches to 12 inches from the ceiling. The halo shall be bonded to the MGB also using a No. 4 AWG bare stranded copper conductor and Engineer approved ground connector.

2.14 COMMUNICATIONS CIRCUIT PROTECTION
A. Related to copper cables that enter all Communications Facilities and Distribution Cabinets (DCs). All signal/communications copper cables shall terminate on Protected Terminal Blocks (PTB) (rack-mounted, wall-mounted or at the Main Distribution Frame (MDF) as per Contract Drawings), and shall conform to these specifications. Where applicable, cable sheath shall be neatly trained and bonded to the MGB (or CGB) using a No. 6 AWG insulated ground conductor.
PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions for compliance with requirements for products specified in this Contract Specifications Section.

B. Note items that may infringe on the necessary clearances and other non-compliances. Promptly bring noted issues to the attention of the Engineer for direction and approval before proceeding.

3.02 GENERAL GROUNDING AND BONDING REQUIREMENTS

A. Provide all grounding and bonding as specified. Where applicable, all building or outside enclosure grounded systems shall be interconnected with the lightning protection grounding system.

B. Grounding conductors shall be protected from physical and environmental damage. Wherever possible, grounding and bonding conductors routed in rooms shall be enclosed in a non-metallic raceway. Exposed conductors, which shall extend from a concrete surface, shall be located as close as possible to a corner. Where conductors are required to run exposed, as in the connection to the main ground bus, grounding conductors shall be supported by corrosion resistant metallic hardware at 4-foot intervals or less.

C. Completely remove all paint, dirt, or other surface coverings at grounding conductor connection points so that good metal-to-metal contact is made.

D. Service grounds and grounding or bonding of electrical service equipment shall be with continuous un-spliced grounding conductor.

E. If an existing facility or outdoor cabinet is being retrofitted, test and, if necessary, upgrade their grounding system to the level specified within these specifications.

3.03 INSTALLATION

A. Grounding Connections

1. Weld buried ground connections exothermically, in accordance with manufacturer’s recommendations. Clean and coat with coal tar epoxy applied with a 32 mils dry film thickness using multiple coats. Allow drying between coats and before backfilling. Encapsulate with epoxy resin all buried ground connections of grounding electrode conductors running to ground buses.

2. Use terminal lug to connect grounding conductor to equipment enclosure. Secure connector or terminal lug to the conductor so as to engage all strands equally by using tools and pressure recommended by the manufacturer. Make connections with clean, bare metal at points of contact.
3. Exothermically weld connections for ground rods in manholes and handholes, or as shown.

4. Splices or soldering in grounding conductors are not permitted.

5. Bolted connections shall not be buried or embedded.

B. Ground Grid

1. Install ground grid consisting of bare solid tinned copper conductors and ground rods buried in earth in the pattern and at the locations shown on site drawings. Ground rods will be minimum 10 foot length, 1 inch diameter. Install ground rods vertically if possible. Where vertical burial is not possible, rods may be at an angle or (as a last resort) buried horizontally 30 inches (minimum) below grade.

2. Bury top of ground rod 30 inches minimum below grade or as shown on Contract Drawings. If extensive rock formation is encountered, relocate ground rods to a new location as approved by the Engineer.

3. Provide 24-inches minimum horizontal separation between ground rods and concrete structures.

4. Interconnect ground rods using bare solid tinned copper conductors as shown on site specific drawings.

5. For Communications Facilities provide two pigtails of grounding electrode conductor of sufficient length above finished floor for connection to the MGB. The two pigtails shall be exothermically welded or bonded in an Engineer approved manner to the grounding grid at a single point.

C. Grounding Bars

1. Install the Telecommunications Main Ground Buss-bar (MGB) as shown on Contract Drawings.

2. Mount the MGB on insulators 2 feet above finished floor using cap screws and expandable threaded anchors, unless shown otherwise on Contract Drawings.

3. Install the distribution cabinet CGB in the bottom of the cabinet, on insulated spacers which electrically isolate them from the cabinet.

4. Provide insulator support at each end of grounding bus-bars and at intervals not exceeding three feet.

5. Bond the grounding electrode conductors to the grounding bus-bar using an Engineer approved ground connector in accordance with this Section.

6. Grounding of Separately Derived ac Power System
7. Bond the safety ground conductor (green wire) to the MGB using a minimum of No. 4 AWG insulated stranded copper wire, as shown on Contract Drawings. For additional guidance refer to the NEC.

D. Grounding for Personnel Safety

1. In Communications Facilities and cabinets, bond equipment enclosures and racks, ductwork, conduit, metal cable trays, the LDF ground bolt, PTB grounds, and the room halo ground ring to the local MGB or CGB using a minimum of No. 6 AWG insulated stranded copper conductor or as specified on Contract Drawings.

2. Wayside metal equipment including, but not limited to, cabinets, poles, pull-boxes, equipment enclosures, and junction boxes: bond and ground each item using No. 6 AWG (minimum) copper conductor to one or more ground rods to provide 3 ohms or less resistance to ground.

E. Electronic Equipment Signal Grounding

1. Electronic equipment shall have separate ‘Signal’ or ‘Telecommunications’ ground connections, which shall be implemented as a separate isolated ‘Signaling’ ground bar (as opposed to a ‘Power’ ground bar) in the equipment rack or enclosure. These connections shall be grounded to the ‘Signaling’ ground bar using a minimum of No. 10 AWG insulated stranded copper conductor and shall be separate from ground connections to the ‘Power’ ground bar. Each rack’s (or enclosure’s) ‘Signal’ and ‘Power’ ground bar shall have an individual connection of a minimum of No. 6 AWG insulated stranded copper conductor to the facility’s or cabinet’s corresponding ‘Signal’ and ‘Power’ TMGB (see below).

2. Where the Communications Equipment Room (CER) is shared with non-communications electronic equipment, a separate TMGB shall be provided. All individual equipment racks or enclosures shall be grounded to the TMGB using a minimum of No. 6 AWG insulated stranded copper conductor.

3. The TMGB shall be grounded to the same point on the ground grid (or to the structural steel) as the electrical service entrance to form a single-point building ground system.

F. Cable Shield Grounding: One end of all cable shields shall be grounded to the TMGB. Use the following guidelines to determine which end of the cable to ground:

1. When a cable goes between CER, ground the shield at the southern most facility.

2. When a cable goes between a CER, and any other facility (TPSS, Signal House, and Distribution Cabinet), ground the shield only at the Communications Facility.

3. Audio cable shield shall be grounded only at CER.
4. When a cable goes between the distribution cabinet and the station equipment, ground the shield at the station. If existing conditions make grounding of the entering cable shield challenging at the existing stations, as per approval by the Engineer the shield grounding can be executed at the distribution cabinet.

G. Fiber Optic Cable Jacket Grounding: Armored jackets (if used) on all fiber optic cables shall be grounded to the MGB using a minimum of No. 6 AWG insulated stranded copper conductor. Where possible, station communication design will use an all-dielectric fiber optic cable plant.

H. Copper Cables Lightning/Surge Suppression: Lightning/Surge Suppression Devices shall be installed at every electric, communication, or data copper cable entrance at the Communications Facility or Distribution Cabinet. The type of the protection device shall correspond to the application specifics of each protected copper cable (as per vendor recommendations) and shall ensure protection of not only ‘working’ conductors/pairs, but also the spares.

3.04 TESTING AND INSPECTION

A. Perform the following inspections and tests on Grounding and Bonding. Notify the Engineer in writing prior to each test and inspection so that the Engineer may be present as desired.

1. Factory Test and Inspection: Perform Factory inspection and testing of the ground terminations for each rack/enclosure ‘Signal’ and ‘Power’ ground bars’ terminations.

2. Field Test and Inspection. Perform the following Field Inspections and Tests:
   a. Inspect ground grid installation, installation depth, conductor sizes, connections to ground rods and foundation rebar prior to backfill, for conformance to Specification requirement.
   b. Inspect installation of all ground bus-bars for proper mounting.
   c. Test ground resistance of each ground grid after installation and each ground bus when connected to ground grid, using Engineer approved test procedure.
   d. Resistance to ground for Communications Facilities and distribution cabinets shall not to exceed three ohms.
   e. To meet resistance requirements, install additional ground rods. If resistance requirements can still not be met, install a sacrificial anode to be approved by the Engineer.
   f. Test metal conduit and raceways, equipment enclosures, metal cable troughs, fences, metal structures, and light poles for ground resistance not to exceed three ohms.
g. Test all GFCI receptacles and circuit breakers for proper ground connections and protection operation with methods and instruments prescribed by the manufacturer.

B. End-To-End acceptance Test: Not required.

C. System Integration Test: Not required.

END OF SECTION
SECTION 17100
COMMUNICATIONS FACILITIES

PART 1 – GENERAL

1.01 DESCRIPTION

A. Section includes requirements for facilities to house equipment for the Station Communications.

1.02 REFERENCE STANDARDS

A. American National Standards Institute (ANSI):

1. TIA/EIA-568 Commercial – Building Telecommunication Cabling Standard

2. TIA/EIA-J-STD-607 Commercial Building Grounding and Bonding Requirements for Telecommunications

B. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):

1. ASHRAE Handbook of Fundamentals, Chapter 26

2. ASHRAE Publication SPCDX (Climate Data for Region X)

3. Gdl 16 Specifying Outside, Return, and Relief Dampers for Variable Air Volume Systems

4. Gld 19P Ventilation and Indoor Air Quality

C. ASTM International (ASTM):

1. A653 Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

2. B3 Specification for Annealed Copper Wire

D. American Society of Civil Engineers (ASCE):

1. ASCE 7 Minimum Design Loads for Buildings and Other Structures

E. California Building Code (CBC)

F. California Electric Code (CEC)

G. Illuminating Engineering Society of North America (IES):

1. RP-7 Practice for Industrial Lighting

H. International Building Code (IBC)
I. Institute of Electrical and Electronics Engineers (IEEE):
   1. 142 Recommended Practice for Grounding of Industrial and Commercial Power Systems (IEEE Green Book)

J. International Organization of Standardization (ISO):
   1. 9001 Recommended Practices and Procedures, Quality Assurance (QA) and Quality Control (QC)

K. National Fire Protection Association (NFPA):
   1. 70 National Electrical Code (NEC)
   2. 72E Standard on Automatic Detectors
   3. 101 Life Safety Code

L. National Electrical Contractors Association (NECA):
   1. NECA 1 Standard Practices for Good Workmanship in Electrical Contracting

M. National Electrical Manufacturers Association (NEMA):
   1. AB 1 Molded Case Circuit Breakers and Molded Case Switches
   2. CC1 Power Connections
   3. PB1 Panelboards
   4. FB1 Fittings, Cast metal Boxes and Conduit Bodies for Conduit and Cable Assemblies
   5. VE1 Metallic Cable Tray Systems

N. Underwriters Laboratories, Inc. (UL):
   1. 50 Safety Enclosures for Electrical Equipment
   2. 67 Panelboards
   3. 467 Grounding and Bonding
   4. 497 Protectors for Paired Conductor Communication Circuits
   5. 969 Marking and Labeling Systems

O. Uniform Building Code (UBC)
1.03 DEFINITIONS

A. “Facilities” shall mean conditioned space required to house station communications equipment primarily at larger stations, where said equipment cannot be confined to an outdoor Communications Interface Cabinet (CIC), also sometimes referred to as Station Communications Cabinet (SCC). This space is commonly referred to as the Communications Equipment Room (CER). Communications Facilities are divided into two types. The facilities required to house the CER shall be a prefabricated shelter (“House”) (Type I) or a space within a new or existing building within or near the station (Type II).

B. Communications Facility, Type I: A stand-alone prefabricated structure, located near (within 500 feet) of the passenger station, that shall house all the required network communications equipment to service the station. Included in this facility shall be the communications carrier equipment (owned or leased) required to link the Central Headquarters in San Carlos, and the Central Control Facility (CCF) with the station, as well as the station subsystem distribution equipment.

C. Communications Facility, Type II: This facility shall be a room within a combined structure to be built or remodeled as an integral part of a station. This Communications Equipment Room (CER) shall contain all the required network and subsystems communications equipment to service the passenger station.

1.04 SYSTEM DESCRIPTION

A. Both Type I and Type II Facilities equipment and infrastructure shall include the following: Fiber Slack Enclosure (FSE), Fiber Distribution Panel (FDP), Main Distribution Frame (MDF), Uninterruptible Power Supply (UPS), AC Distribution Panel, lightning protection and grounding, HVAC, static dissipative tile (SDT) floor, Intrusion Alarm Panel, and other support systems as described in detail in this Section.

B. Design, provide and install Type I Facilities (herein after known as Houses) as described herein. Each house shall be prefabricated for communications equipment in accordance with this Section and the Contract Drawings.

C. Type II Facility is a room within a combined electrical/mechanical/communications structure, typically located within the station. Refer to the Contract Drawings for location of such room or rooms, if applicable. The Communications Equipment Room (CER) shall be dedicated to station communications and will have controlled access. Refer to the Contract Documents which indicate new or existing normal and emergency power system, fire alarm system, and HVAC system which will serve the CER. Design, provide and install all required communications equipment in accordance with this Section and the Contract Drawings.

D. Communications Facilities, Types I and II shall be equipped with proper fire extinguishers and fire monitoring systems as described in these specifications.

E. Communication Facilities Type I shall be sized and configured and Type II shall be configured based on the following guidelines:
1. An unobstructed area of open wall shall be dedicated for wall mounted termination and wiring blocks, panels, building entrance protectors, and outside plant cable splice enclosures. This area commonly referred to as the Main Distribution Frame (MDF) also serves as the MPOE termination point. Adequate space shall be planned so that initial (day-one) installation will not consume more than 50 percent of the total available MDF space.

2. Open equipment racks or cabinets shall house communication equipment, UPS, and other network and distribution equipment. Each rack or cabinet shall be assigned by system type such as network carrier, video server, or UPS. Adequate space shall be planned to allow system equipment expansion per rack or cabinet. At least 50 percent of the available mounting space of each rack or cabinet placed shall be reserved for future equipment. Should any rack or cabinet exceed 50 percent on initial installation, the facility floor plan shall reserve an empty rack or cabinet for future equipment deployment.

3. An unobstructed work clearance of three (3) feet to the front and rear of equipment racks and cabinets, and the MDF, shall be provided.

4. Adequate heating, ventilation and, if required by calculations, air-conditioning shall be sized and provided for the Communication Facilities. The HVAC equipment power and thermo calculations shall be based on the initial (day-one) installation load plus additional 50 percent of the similar load (reserved to accommodate future growth).

5. Building or room access doors shall not hinge or swing into equipment areas. The design of the building and the room access doors shall accommodate intrusion detection and access control systems.

6. The design of the building or room (including equipment to be installed inside) shall meet California Building Code (CBC), International Building Code (IBC), Uniform Building Code (UBC), Seismic Zone 4 and other requirements listed within these Specifications.

1.05 SUBMITTALS

A. Refer to Section 17000, Basic Communications Technical Requirements, for related and additional submittal requirements.

B. Preliminary Design Review (PDR) Technical Requirements:

1. Include the following information as part of the PDR submittal package for Type 1 Communications Houses:

   a. Drawings showing the House dimensions, layout (plan and elevations), and external architecture.

   b. Architectural and Construction Details, including House and foundation reinforcing drawings.
c. Calculations signed and sealed including structural, heating/cooling, seismic (for overall building and floor, ceiling, and wall mounted infrastructure and bracing), lighting, and electrical power requirements.

d. Lightning Protection and Grounding Arrangement such as ground grid and room halo.

e. Cable Trays and Battery Racks.

f. Ac and dc Power Distribution, UPS Equipment and Lighting.

g. Fire, Access Control and Intrusion Alarm Subsystems Equipment Location, including the fire extinguisher.

h. Cable and conduit Entrance/Exit (and other protrusions) Details including firestop and water/moisture protection.

i. External Interface Details for Power and Communications Connections.

j. Plan and Elevation Drawings for MDF and wall-mount distribution panels, Equipment Cabinets, Racks, Lighting and Cable Trays.

k. HVAC equipment details.

l. Product specifications for lighting, cable trays, HVAC equipment.

m. Additional Product Data Sheets, as required for subcomponents.

n. SDT data and details.

2. Include the following information as part of the PDR submittal package for the Type II Communications Facilities:

a. Dimension drawings, plans and elevations, showing layout of equipment.

b. Ac and dc Power Distribution, including interface details for Power Connections, UPS equipment, and Lighting.

c. Calculations signed and sealed including structural, heating/cooling, seismic (for floor, ceiling, and wall mounted infrastructure and bracing), lighting and electrical power requirements.

d. Product specifications for all provided materials.

e. Fire, Access Control and Intrusion Alarm Panel equipment.

f. Plan and Elevation Drawings for MDF and wall-mount distribution panels, Equipment Cabinets, Racks, Lighting and Cable Trays.
g. Cable Trays and Battery Racks.

h. Cable and Conduit Entrance/Exit (and other protrusions) Details including firestop and water/moisture protection.

i. HVAC equipment details.

j. Grounding Arrangement such as ground grid, room halo, and Telecommunication Main Ground Buss-bar (MGB).

k. SDT data and details.

C. Final Design Technical Requirements: Submit, after Preliminary Design approval, the following information as part of the Communications Facilities Final Design submittal package:

1. Updated Preliminary Design information. All drawings, calculations and design information required for the final design.

2. Final and detailed wiring drawings ready for construction and installation.

3. Final equipment list.

4. Final equipment installation details.

5. Final cable and equipment identification.

D. Installation Work Plans: Submit the following installation document for each site scheduled for installation activity. The installation Work plan shall include:

1. Site Plans and Foundation Drawings:
   a. Drawings showing plan and elevation details of the foundation and the ductbank, including the man-hole interface.
   b. Site plans for the Communications Houses.
   c. Installation Plan to include:
      i. Planned access dates and times for each location
      ii. Safety rules, regulations and procedures
      iii. Caltrain resources required
      iv. Daily preparation and cleanup procedures
   d. Delivery and Installation Procedures and Inspection Sheets:
      i. The procedures submitted shall include descriptions of the equipment used for transport and setting of the Communications Facility.
ii. Complete Inspection Sheets and submit to the Engineer within seven days after installation of the Facility.

E. Calculations and Certifications:

1. Provide calculations as listed in the Preliminary Design and Final Design. Calculations shall be signed and sealed by a California Licensed Professional Engineer.

2. Certifications: Copy of the following certifications shall be included:
   a. ISO certification for all proposed manufacturers
   b. Certificates and permits for all Facilities

F. Product Samples:

1. Provide sample color chips of the facilities finish coat for Engineer approval.

2. Provide pictures and facilitate factory visit for a typical sample Communications facility for Engineer approval.

3. Submit sample of address signage for Engineer approval.

4. Submit sample of Access Control identification for Engineer approval.

G. Manufacturer Qualifications: Submit evidence that manufacturer complies with manufacturer qualifications specified in Section 17050, Basic Communications Equipment, Materials, and Methods.

H. Test Plan and Procedures: In accordance with these Specifications, specifically with the format and requirements detailed in Sections 17000, Basic Communications Technical Requirements, and 17050, Basic Communications Equipment, Materials, and Methods, as a minimum, submit, no later than 60 days prior to the schedule test, the following plan and procedures to satisfy the Communications Facilities testing requirements

1. Test program plan: Include all the required information for the Communications Facilities in the Test Program Plan as outlined in Section 17000, Basic Communications Technical Requirements.

2. Factory and Inspection Test Procedure: Submit a complete factory test and inspection procedure to satisfy all the requirements outlined in Article entitled “Source Quality Control” of this Section.

3. Field Test Procedure: Submit a complete field test procedure to satisfy all the requirements outlined in Article entitled ”Field Quality Control” of this Section.

I. Test Records: Submit the Test Records and Results for review 14 days after the completion of each test, in accordance with these Specifications.
J. As-Built Documentation: Submit complete As-Built documentation and drawings, as specified in Section 17000, Basic Communications Technical Requirements, for all Communications Facilities and contents.

1.06 QUALITY ASSURANCE

A. Applicable Standards and Codes:

1. Fabrication, inspection, installation and testing shall comply with all applicable Standards and Codes as listed herein.

2. Equipment and methods shall comply with applicable codes and standards listed under Reference Standards herein.

B. Material and Workmanship Requirements:

1. Equipment provided under this Section shall be UL listed.

2. Grounding shall be in accordance with local standards, Section 17060, Grounding of Communications Equipment, and these Specifications except as modified herein. Each piece of equipment shall be grounded in accordance with ANSI/TIA/EIA-J-STD-607-A.

3. Products shall be manufactured by firms regularly engaged in manufacturing products described in these Specifications.

4. Factory testing shall be performed by persons having five or more years of relevant testing experience

5. Do not use discontinued product models, refurbished equipment, products at their end-of-life, end-of-sale, or end-of-service.

6. Products specified herein are subject to the Engineer approval based on the Contractor's ability to demonstrate adherence to the requirements of these Specifications and Engineer approval of the manufacturer’s quality ISO-9001 process.

PART 2- PRODUCTS

2.01 TYPE 1 COMMUNICATIONS FACILITY CONSTRUCTION

A. Structural and Architectural:

1. Communications House shall be prefabricated, climatized, self-supporting and transportable. The houses shall be weathertight and be free from defective materials and workmanship, water leakage and seepage, and condensation.

2. The minimum headroom inside Communication House shall be 10 feet.

3. Communications House roof shall be fabricated from 14 gage, and walls, floor, and doors shall be fabricated from 12 gage galvannealed steel conforming to ASTM A653.
4. Following assembly, any areas exposed to outside atmosphere that have been affected by cutting or welding shall be spot galvanized with a primer that forms a dry film of no less than 90 percent pure zinc.

5. Exterior roof shall be finished with 2 to 3 mils thick white polyester powder coat. Underfloor and exterior walls shall be finished with 2-3 mils thick anti-graffiti grey polyurethane powder coat.

6. Exterior seams shall be caulked with grey RTV silicone.

7. House shall be insulated with 2 inch thick fiberglass-faced polyisocyanurate rigid insulation on walls and doors, and 4 inch fiberglass faced rigid insulation above trusses.

8. Design loading for floor shall be at least 200 pounds per square foot.

9. House shall be equipped with lifting lugs for shipping and installation.

10. Interior walls shall be covered with 3/4 inch thick MDO plywood as shown on the Contract drawings.

11. Interior walls and ceiling shall be finished with 2 coats of white fire retardant paint.

12. Steps: Reinforced concrete steps shall be provided if the lowest point of the doorway entrance is greater than one foot above ground level.

13. Doors shall be 32 inches wide and a minimum of 84 inches high. Doors shall include the following features:
   a. Hinges: Vandal-resistant bolt on stainless steel hinges with grease fittings.
   b. Lock: Heavy duty three point locking system with interior safety override handle and exterior handle with a heavy duty security hasp.
   c. Prop rod to hold door open at 90 and 160 degrees.
   d. Louvered vent with winter cover, fine copper screening, and reusable filter.
   e. Weatherstripping: Provide weatherstripping and flashing for openings such as doors and removable panels to exclude water entry under all weather conditions. Where necessary, use EDPM extruded rubber gasket providing weathertight seal.
   f. Heavy duty security hasp.

14. Flooring:
   a. Flooring shall be formed of STD, 1/8 inch thick by 12 inches square, Armstrong Excelon SDT or Engineer approved equal.
b. STD adhesive and grounding strips, followed by the tile, shall be placed directly on the floor in the manner and under the conditions recommended by the manufacturer. Tile shall be polished using the SDT polish recommended by the manufacturer. Tile color shall be submitted for Engineer approval.

c. Grounding strips to be grounded to the MGB in accordance with tile manufacturer’s recommendations.

B. Foundation:

1. The foundation system shall be pad mount style for buried or pad foundations. Concrete mix shall be as specified in Section 03300, Cast-in-Place Concrete.

2. The foundation shall be designed and installed in accordance with these Specifications.

3. The slab shall be reinforced as shown on the approved Contractor-provided design drawings. Slab reinforcement shall include provisions for leave-outs for conduit penetrations.

4. At each corner of the slab, a No. 2 AWG bare solid tinned copper ground wire shall be welded to the reinforcing bars. The other end of this ground wire shall be welded to the nearest ground rod as required by these Specifications and as shown on the site specific drawings.

C. Ductbanks:

1. Provide a ductbank from the Communications/Signals manhole to the Communications House penetrations for underground conduits. Ductbank shall be reinforced concrete as specified in Section 02500, Underground Ductwork and Structures.

2. The Contractor shall locate a plastic warning tape, as specified in Section 02300, Earthwork, between the ductbank and the finished grade surface and 12 inches above ductbank.

3. Conduit spacing within the ductbanks shall be accomplished with manufactured plastic conduit spacers.

4. All conduits within ductbanks shall be Schedule 40 PVC. Where conduits transition to occupied spaces (e.g. the Communications House), galvanized rigid steel conduits shall be used.

5. The depth of the manhole will vary from site to site. Be responsible for the excavation of ductbank as required to interface with the manhole. Provide the interface with the manhole as shown on Contract Drawings.

D. Address Signage:

1. Communications Facility shall be provided with an address signage on the side of the exterior door for identification.
2. The sign shall have a white, reflective background with 3 inch black lettering.

2.02 TYPE I COMMUNICATIONS FACILITY EQUIPMENT

A. Electrical:

1. Electric power for the Communications House shall be obtained from the Local Electrical Utility as shown on the Contract Drawings. Provide and install the cable and conduit required for the main ac feed to the Communications House as shown on the Contract Drawings.

2. Equip the Communications Facility with a 120/240Vac single phase electrical panel board rated according to the Engineer approved calculations. As a minimum, the electrical panel shall be 100 Amp panel board. A transient voltage surge suppressor, meeting the requirement of NEC Article 280, shall be provided for the panel board. The electrical panel shall be equipped with a main circuit breaker rated according to the Engineer approved calculations. As a minimum, a 100 Amp main circuit breaker shall be provided. Sixteen branch breaker slots shall be provided with a minimum of 16 breakers equipped. Breakers shall be labeled with the corresponding equipment or system circuit feeds. One (1) 120/240 Vac EPD surge protector shall be provided.

3. Duplex 20A receptacles shall be provided at intervals of approximately 6 feet along walls. Electrical boxes shall be in accordance with these Specifications.

4. L5-30 locking 30A receptacles shall be provided where required by the specified Uninterruptable Power Supply (UPS).

5. Six (6) fluorescent tube fixtures, 24 inches in length, with 4 tubes per fixture and wrap lens, shall be provided.
   a. The light level shall be adequate for reading with an average level of 50 foot-candles.
   b. A 20A SPST light switch located adjacent to the door shall operate the fixtures.

6. All indoor power cable runs shall be in electrical metallic tubing (EMT) conduit and secured with single-hole straps.

7. Two electro-tin plated solid copper grounding buss bars, the Telecommunications Main Grounding Bus-bar (MGB), shall be installed at a height of 18 inches, and attached with insulated brackets as required by these Specifications. Equipment, cables, racks, and cable trays, shall be grounded to this buss-bar as required by these Specifications and the Contract Drawings.
8. Ground test stations shall be provided, along the bottom and inside wall of the house and shall be interconnected by an insulated copper cable sized at no less than 250 kcmil.

9. UPS and batteries as required by these Specifications.

10. A separate 120V ac power panel shall be provided for power output from the UPS. Main lugs rated at 225 Amp shall be provided. Thirty breaker slots shall be provided with a minimum of 12 breakers equipped. All active slots shall be labeled with the equipment to which the circuit feeds. Ac power to individual equipment racks shall be individual home runs from the UPS breaker panel, and shall be enclosed in EMT conduit.

11. A Main Distribution Frame (MDF) shall be provided at the entrance way for the cable entrance conduits as shown on the Site specific drawings. The MDF shall conform to these Specifications.

12. Equipment cabinets shall be provided for and equipped complete with communication equipment as required on the Contract Drawings. Cabinets shall conform to these Specifications and site specific drawings.

13. FSE shall be provided as shown on the site specific drawings. Enclosure shall conform to these specifications.

14. A room halo ring ground shall be provided. The halo shall be made from No. 4 AWG bare stranded copper conductor, and be bonded to the MGB as required by these Specifications.

15. A 120 Vac battery backup green Light Emitting Diode (LED) type exit light shall be provided and installed over the doorway. The LED lamp life shall be rated for 25 years. The battery shall be a Ni-cad type and shall have 90 minutes capacity.

16. Telephones shall be installed and tested as required by these Specifications and the Contract Drawings.

B. Heating, Ventilation and Air Conditioning (HVAC): Equip communications house with HVAC equipment rated according to the approved thermo calculations in the design submittals. As a minimum, HVAC equipment shall be equipped with a thermostatically controlled 5000 watt resistant heater and 18,300 BTU air conditioner. Temperatures within the house shall be regulated within the range of 60 degrees Fahrenheit (F) to 80 degrees F with ambient temperatures in the range specified by the Specifications.

1. The temperature within the equipment cabinets shall not exceed ambient air temperature within the house by more than 10 degrees F.

2. The outside of each air conditioner shall be protected with a hinged, heavy gauge, hot-dipped, galvanized vandal-resistant security mesh cage. The cage shall be constructed with a slot on the frame that, when in its closed position, will not pinch the air conditioner’s condensation drainage tube.
a. The cage shall be constructed of an angle iron frame and be enclosed with 1-1/2 inch x 10-gauge steel expanded metal to form a five-sided box.

b. The cage shall be hinged to swing horizontally open to allow for 90 degrees maintenance access. Two locking hasps shall be provided to hold the cage in the closed position. A mechanical device shall be provided for securing the cage in the 90 degrees opened position. Cage design shall allow for a single maintenance technician to gain access and perform any maintenance activity on the HVAC unit.

c. The cage shall be attached to the wall using tamper-proof screw/bolts with anchors cast into the wall during manufacturing to ensure mounting integrity.

d. The cage shall have an oversized width, additional 1 foot minimum, on the hinged right side to accommodate air conditioner maintenance.

3. An exhaust fan with manual and thermostatic control shall be provided. The thermostatic control of the exhaust fan shall prevent simultaneous operation of the fan and air conditioner Compressor. The exhaust fan shall include rain hood and controlled louvers with 1/4 inch wire mesh screen. The fan shall be rated according to approved thermo calculations and shall as a minimum have 1000 CFM capacity.

4. All penetrations through the walls, floor, and roof shall be sealed to prevent water from entering the House.

5. The HVAC system shall provide separate alarm contacts for unit failure and both high and low temperature, which will be connected to the local UPS Alarm dry contacts (and to RTU in the future) and programmed for monitoring. An LED indication shall be provided within the House to show when the alarm is active.

6. The HVAC system, upon a Fire Alarm condition as detected by the House’s Fire and Intrusion Alarm Subsystem equipment, shall automatically and within four seconds, initiate actions to:

   a. Shut off the air conditioning unit(s)
   b. Close dampers

C. Cabinet Ventilation: Cabinets that contain heat-generating equipment shall be provided with adequate ventilation. In particular, cabinets and compartments housing essential electronic equipment, shall be designed to provide adequate ventilation so that for any device inside its maximum temperature stays below its rated operating temperature with a margin of at least 10 degrees Celsius. If required in order to avoid overheating, the Contractor shall provide forced air ventilation inside such enclosures, including alarms.
D. Cable Tray: Cable trays shall be provided in accordance with the Engineer approved House layout plans. Cable trays shall be as required in the Specifications and Contract Drawings.

E. Fire and Intrusion Alarm Subsystems: Provide fire detection and alarm system conforming to NFPA 72E, complete with ionization detectors, dual ion zone module, control panel, end-of-line device, power supplies and all other items of material and equipment required for a complete installation. The Fire and Intrusion Alarm Subsystems, shall be installed and tested as required by the Specifications.

F. Equip house with a 20 pound dry chemical fire extinguisher.

G. Exterior lighting shall include a weatherproof, wall mounted area lighting fixture above each doorway. The exterior lighting shall be on a separate circuit, and shall be controlled by a switch with three positions as follows: ON, OFF and AUTO. In the AUTO position, the exterior lighting shall be controlled by a photoelectric cell.

H. Communications System Equipment: Additional communications system equipment such as LAN/WAN, PAS, VMS, TVM, Clipper CID and/or CCTV, including all related hardware integral with the cabinets, shall be installed in the communications house as shown on Contract Drawings and as described in the Specifications.

2.03 TYPE II COMMUNICATIONS EQUIPMENT FACILITIES

A. Provide and install the following equipment at each Type II Facility:

1. UPS and batteries as required by the Specifications.

2. A 120V ac power panel fed from the output of the above UPS. Panel shall have 30 breaker slots and be provided with a minimum of 12 breakers sized as shown on the Contract Drawings.

3. An electro-tin plated solid copper grounding buss-bar, the Telecommunications Main Grounding Bus-bar (MGB), shall be installed at a height of 24 inches, attached with insulated brackets as required by the Specifications.

4. Equipment, cables, racks, and cable trays shall be grounded as required by these Specifications and the Contract drawings.

5. A Main Distribution Frame (MDF) shall be provided at the entrance way for the cable entrance conduits as required by these Specifications and as shown on the Contract Drawings.

6. FSE shall be provided as shown on the Contract Drawings. Enclosures shall conform to the Specifications.

7. Fiber Distribution Panel (FDP) shall be provided as required by these Specifications and as shown on the Contract Drawings.
8. A room halo ground ring shall be provided. The halo shall be made from No. 4 AWG bare stranded copper conductor, and be bonded to the MGB as required by the Specifications.

9. Cable trays shall be provided in accordance with the Authority approved facility room layout plans. Cable trays shall be as required by these Specifications and the Contract Drawings.

10. Equipment cabinets shall be provided for and equipped complete with communication equipment as required by the Specifications and Contract Drawings.

11. Equipment cabinets shall have fans located in the top to provide for air circulation. Cabinet ventilation openings shall have replaceable filters to prevent the intrusion of dirt.

12. Access Control and Intrusion Alarm Control Panel equipment shall be installed and tested as required by the Specifications.

13. Fire detection equipment (as an integral part of the combined facility fire detection system), including the fire extinguisher shall be provided in accordance with the Specifications.

14. Telephones shall be installed and tested as required by these Specifications.

15. Flooring: As specified for Type 1 Communications Facility Construction in this Section.

16. All exposed wiring shall be run in conduits as required by these Specifications.

17. A 120Vac battery backup green LED type exit light shall be provided and installed over each doorway. The LED lamp life shall be rated for 25 years. The battery shall be a NiCad type and shall have 90 minutes capacity.

18. Electrical service equipment shall include the following:
   a. HVAC equipment
   b. Interior Lighting
   c. Access Control, Fire Detection and Alarm system
   d. MGB and related grounding cables

B. Cabinet Ventilation: Cabinets that contain heat-generating equipment shall be provided with adequate ventilation. In particular, cabinets and compartments housing essential electronic equipment shall be designed to provide adequate ventilation so that for any device inside its maximum temperature stays below its rated operating temperature with a margin of at least 10 degrees Celsius. If
required in order to avoid overheating, the Contractor shall provide forced air ventilation inside such enclosures, including alarms.

C. Communications System Equipment: Additional communications system equipment such as WAN/LAN, PAS, VMS, TVM, Clipper CID, and/or CCTV, including all related hardware integral with the cabinets, shall be installed in the communications house as shown on Contract Drawings and as described in the Specifications.

2.04 SOURCE QUALITY CONTROL

A. Monitor the fabrication of the Houses to ensure that all structural requirements are adhered to.

B. Inspection: Inspect the Communications House prior to shipment to a site. Notify the Engineer no later than 21 days prior to this inspection.

C. Perform the following Factory Inspection (Communications Facilities, Type 1 only). Provide the Engineer at least 21 days written notification prior to each test and inspection.

1. Provide Factory inspection procedure for Authority approval at least 21 days prior to scheduled inspection.

2. Inspect the House at the Factory for cracks and other damage, and repair to the satisfaction of the Engineer.

3. Inspect the House at the Factory for level and plumb; proper operation of doors and dampers; proper location and installation of HVAC equipment breaker panels, lighting fixtures, electrical outlets, fire and intrusion sensors and equipment; cable trays, and other equipment.

4. Inspections shall verify:
   a. Conformance to standards, methods, and quality.
   b. Correct location, positioning, seating, mounting, orientation, and labeling.
   c. Secured cable and wire connections.
   d. Proper routing and termination of wire and cable.
   e. Proper equipment grounding.
   f. Correct and complete labeling and tagging of wire, cable, terminal, connectors and equipment.
   g. Conformance to installation requirements.

5. Provide inspection results for Engineer approval 14 days after the completion of an inspection,
PART 3 - EXECUTION

3.01 INSTALLATION

A. Foundation and Placement of the Communications House:

1. Perform site preparation in accordance with Section 02110, Site Clearing.

2. Refer to Section 02300, Earthwork, for requirements for excavation and backfill for the Communications House site.

3. The foundation and anchor bolt locations shall be of depth and size to support the prefabricated shelter in accordance with the approved drawings. Concrete formwork and concrete reinforcement shall be in accordance with Contractor-provided design and Division 3, Concrete, Specifications Section.

4. Install the House level and plumb on the foundation. Apply waterproof, non-hardening sealing compound between the foundation and house base perimeter.

5. Provide and install a ballast skirt surrounding the House. The skirt material shall be consistent with the ballast specified in Section 20110, Ballast and Walkway Aggregate. Ballast shall be a minimum depth of 12 inches and at least five feet wide, extending from the communication house foundation outward and consistent with the other wayside structures sharing the common location.

6. A ballast path shall extend from the Communications House door to the nearest driveway, parking area, or improved access point. The path material shall be consistent with the ballast specified in Section 20110, Ballast and Walkway Aggregate. Ballast shall be a minimum depth of 12 inches and at least 3 feet wide, and consistent with the other wayside structures sharing the common location.

B. Cable Entrance Conduits:

1. Install eight 4-inch schedule 40 PVC conduits from a Communication System Manhole (CSMH) to the House, and stubbing up through the House floor foundation. As the conduits enter the communications house, provide a matching coupling and Galvanized Rigid Steel (GRS) conduit above the floor. Provide an additional conduit, for ground conductors, which will pass through the slab and extend approximately 18 inches beyond the edge of the slab. These conduits shall be installed in the pattern provided on site specific drawings and as required by the Specifications.

2. The cable entrance conduits shall sweep into the House through the foundation. The sweep radius at the entrance conduits shall be greater than the minimum radius required for the fiber optic cable as required by these Specifications.
3. The entrance conduits shall be encased in a concrete reinforced ductbank as shown on the Contract Drawings and as required by these Specifications. Provide the interface with the CSMH as shown on Contract Drawings.

4. Seal around the conduits with a permanent, waterproof and fire-stopper sealing compound as required by these Specifications. After all cables have been installed, fill the conduit openings with fire-stopper duct sealant in order to prevent moisture from entering the House.

5. The cable entrance conduits shall be as required by these Specifications.

C. Grounding:

1. Install, as a minimum, one ground rod outside each corner of the House, and the connecting ground wire, as shown on the Contract Drawings.

2. Grounding shall be as required by these Specifications and the Contract Drawings.

3. The electrical power systems shall be grounded as required by these Specifications, and as shown in the Contract Drawings.

3.02 FIELD QUALITY CONTROL AND TESTING

A. Perform the following field inspections and tests on all Communications Facilities. Give the Engineer at least 21 days written notification prior to each test and inspection.

1. Field Inspection:
   a. Prior to installation, inspect with the Engineer the foundation and conduit stub-ups and anchors to verify that they conform to Contract Drawings. Record discrepancies on a discrepancy list; immediately submit the list to the Engineer; and proceed to correct discrepancies.
   b. Field inspection shall include inspection of each installed communications facility. Process inspections are required.
   c. The inspection shall confirm that:
      i. The installation drawings and procedures define the installation adequately and in sufficient detail, such that if the procedures are followed, the resulting installation will meet Engineer approved standards, practices and procedures for workmanship, maintainability, referenced installation standards, installation requirements, these Specifications, the site specific drawings, and the installation requirements of local jurisdictions.
      ii. Should the Engineer decide that the installation drawings and procedures are inadequate, revise any such
drawings and procedures prior to performing installation Work.

iii. The installation drawings and procedures shall adequately provide for the safety of installation personnel. If not, the installation procedures shall be revised prior to performing installation Work.

d. Inspection shall verify:

i. Conformance to installation requirements

ii. Conformance to standards, methods and quality

iii. Proper routing and termination of wire and cable

iv. Secured cable and wire connections

v. Proper grounding of all equipment

vi. Correct and complete labeling and tagging of wire, cable, terminal, connectors and equipment.

e. Provide all the inspection records and results required in this Section to the Engineer within 14 days after each inspection.

2. Field Tests: Perform the following field tests:

a. Verify operation of main circuit breaker and all feeder circuit breakers.

b. Measure resistance to ground from all ground points, including those located in equipment cabinets. Measured resistance shall not exceed 3 ohms as required by these Specifications.

c. Verify operation of all lighting.

d. Verify operation of HVAC equipment, including heaters, air conditioner, exhaust fan as well as all thermostatic controls.

e. Verify operation and reporting of the communications facility alarm indications including those related to fire, intrusion, power and HVAC (visual and audio) both locally and at the Central Control Facility (CCF).

f. Verify operation of dampers and HVAC unit in the event of fire alarm conditions.

g. Verify operation of all equipment controls and indicators.

h. Provide all test records and results required in this Section to the Engineer within 14 days after each test.
B. End-To-End Acceptance Test: Acceptance testing will be limited to the field tests described above. There is no requirement for End-to-End Acceptance Test for the Communications Facilities.

C. System Integration Test: System Integration Test will be directed by the Engineer. Provide qualified technical staff to support this test as required by these Specifications and the Engineer.

END OF SECTION
SECTION 17120

COMMUNICATIONS WIRES AND CABLES

PART 1 – GENERAL

1.01 DESCRIPTION

A. Section includes requirements for wires and cables, cable connectors, and other related materials.

1.02 REFERENCE STANDARDS

A. American National Standards Institute (ANSI):

1. ICEA S-87-640 Fiber Optic Outside Plant Communications Cable
2. J-STD-607-A Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications

B. American Railway Engineering and Maintenance of Way Association (AREMA):


C. ASTM International (ASTM):

1. B3 Specification for Soft or Annealed Copper Wire
2. D1248 Specification for Polyethylene Plastic Extrusion Material for Wire and Cable
3. D4101 Specification for Propylene Injection and Extrusion Materials
4. E814 Test Method for Fire Test of Through - Penetration Fire Stop

D. Building Industries Consulting Services International (BICSI):

1. Telecommunications Distribution Methods Manual (TDMM)


1. 7 CFR 1755.890 RUS Specification for Filled Telephone Cable with Expanded Insulation
2. 7CFR 1755.900 RUS Specification for Filled Fiber Optic Cables
3. 7CFR 1755, Bulletin 1753F-201 RUS Specification for Acceptance Tests and Measurements of Telecommunications Plant

F. Code of Federal Regulations, Railroad Administration (FRA)
G. California Build Code (CBC)
H. California Electric Code (CEC)
I. Electronics Industries Alliance (EIA):
   1. 310 Cabinets, Racks, Panels, and Associated Equipment
J. Institute of Electrical and Electronic Engineers (IEEE):
   1. National Electrical Safety Code (NESC)
K. Insulated Cable Engineers Association, Inc. (ICEA):
   1. S-84-608 Filled Telecommunications Cable, Polyolefin, Insulated, Copper Conductor
L. National Electrical Contractors Association (NECA):
   1. 1 Standard Practices for Good Workmanship in Electrical Construction
M. National Electrical Manufacturers Association (NEMA):
   1. WC 7 Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
   2. WC 70 Nonshielded Power Cables Rated 2000 Volts or less for the Distribution of Electrical Energy
   3. WD 1 General Requirements for Wiring Devices
N. National Fire Protection Agency (NFPA):
   1. 70 National Electrical Code (NEC)
   2. 70E Electrical Safety in the Workplace
   3. 72 National Fire Alarm Code
   4. 75 Protection of Electronic Computer Data Processing Equipment
   5. 101 Life Safety Code
   6. 130 Fixed Guideway Transit Systems and Passenger Rail Systems
   7. 262 Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces
   8. 780 Installation of Lightning Protection Systems
O. Telecommunications Industry Association/ Electronics Industries Alliance (TIA/EIA):
1. 455 Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Connecting and Terminating Devices and Other Fiber Optic Components

2. 492CAAB Detail Specification for Class IVa Dispersion-Unshifted Single-Mode Optical Fibers with Low Water Peak

3. 568 Commercial Building Telecommunications Cabling Standard

4. 569 Commercial Building Standard for Telecommunications Pathways and Spaces

5. 606 Administration Standard for the Telecommunications Infrastructure

P. Telecommunications Industry Association (TIA):

1. 598 Optical Fiber Cable Color Coding

Q. Underwriters Laboratories (UL):

1. 444 Communication Cables

2. 497 Standard for Safety Protectors for Paired Conductor Communications Circuits

3. 969 Standard for Marking and Labeling Systems

4. 1581 Reference Standard for Electrical Wire, Cable, and Flexible Cords

5. 1690 Data-Processing Cable

**1.03 SYSTEM DESCRIPTION**

A. Material and workmanship of the cables shall be consistent with the following requirements:

1. The life expectancy of the cable shall be minimum 40 years in a railroad environment.

2. The cable shall be constructed for continuous operation at 90 degrees Celsius, in a wet or dry environment.

3. Conductor to conductor and conductor to ground resistance shall not be less than one mega-ohm.

4. Cable shall be constructed for continuous operation at minus 40 degrees Celsius without cracking or becoming brittle.

B. Design, installation, and testing shall comply with all applicable standards and codes listed under Reference Standards in this Section. The installation of power wire and cable shall conform to all applicable NEC standards. Installation of data
1.04 SUBMITTALS

A. Refer to Section 17000, Basic Communications Technical Requirements, for related and additional submittal requirements. Submit additional submittals upon Engineer’s request.

B. Submit product data wires and cables including complete technical information for each type cable.

C. Submit Conduit fill calculations not to exceed the NEC specified fill ratios.

D. Submit wire size calculations for all copper cables to determine voltage drops, and proper capacity for voltage, current and distance for all feeder, branch and device power; Ethernet (and, if applicable, serial) data and audio applications.

E. Submit a written cable installation procedure and check-off list for approval prior to cable installation. Prepare procedure based on Contractor’s review of the conduit plans, and field site survey and shall include a cabling plan and installation information for each cable pull. The installation plan shall include proper procedures for feeding cable into conduit to maintain proper bend radii, and to minimize friction. The documentation shall include details of cable lightning/surge protection and grounding.

F. Identification Submittals: Submit wire designations scheme for the Engineer’s approval. Submit sizes of letters and nature of wording for labels, number plates, and warning notices.

G. Submit cable test plan at least 30 days in advance of testing: tests to be made, format and layout of test forms and reports, and the limiting values to be used.

H. Submit manufacturers’ qualifications.

I. Submit certified test reports.

J. As-Built Documentation: Refer to Section 17000, General Communications Technical Requirements, for requirements. Show all terminations, wire and cable labels/numbers, with interconnected equipment.

1.05 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with all applicable codes and specifications.

B. Manufacturer Qualifications: Obtain Engineer’s approval of all wire and cable manufacturers. Provide data required for evaluation, and make arrangements for any demonstrations and tests required by the Engineer.

C. Qualifications shall be based on the following criteria:
1. Past Performance and Experience: The cable manufacturer(s) 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.

2. Quality Assurance Program: The cable manufacturer(s), in accordance with the requirements of these 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 Engineer’s inspection of manufacturing facilities may include first article inspections, source inspections, and on-site surveys.

3. Technical Data: Provide full technical data that demonstrates compliance with the requirements of these Specifications for each specified cable type proposed to be supplied.

1.06 PRODUCT DELIVERY, HANDLING AND STORAGE

A. Packing: All cable barrels/spools/drums shall not be less than twenty (20) times the finished cable nominal diameter, but not less than the minimum bending radius. Seal all ends of the cable to prevent entrance of moisture.

B. The following particulars shall be stenciled or painted in a permanent manner on the outside of the flange of each drum.

1. Metallic cable shall have the words “Telecommunication Cable”

2. The manufacturer’s identification of the cable type and date of manufacture

3. Gross weight of Reel and Cable

4. Full description of the cable

5. Cable identification number, which is referenced to the test sheet

6. Length of Cable

7. An arrow showing the direction in which the drum should be rolled to gain access to the cable.

C. Handling: Cable drums shall be complete with close fitting wooden battens to prevent damage to the cable during transit and storage.

D. Acceptance at Site: Examine drums at installation storage area for external damage. Damaged cables will not be accepted. Inspect cables at time of delivery to the construction site to assure that no damage was done in shipping and that the specified cable was received. Inspect every reel for physical damage such as nails driven into reels to secure shipping blocks, lagging, or reel covering missing and cable and seals missing or damaged. Replace promptly all damaged or rejected cable. Conduct fiber loss (OTDR) testing on the fiber cable and continuity and cross-talk testing for the copper cabling to ensure all delivered cabling is within the vendor specified performance range upon arriving.
to the site. All defective and/or underperforming cables shall be returned and substituted with the product meeting specifications. Provide to the Engineer the results of the delivery acceptance tests.

E. Storage and Protection: Store drums with flanges upright. Store cable on drums with batten in place indoors. Store wires and cables at the construction site on solid surfaces, which shall adequately support the cable reels, but which shall be well drained and not allow accumulation of liquids, oils, or chemicals.

F. Align and protect cable reels so as not to allow the reel flanges to damage other reels. Provide adequate aisles and barricades to allow for accessibility but prevent construction equipment from damaging the cable reels.

PART 2 – PRODUCTS

2.01 DATA CABLE

A. Local distribution of data circuits for all system shall be by CAT 6 cable.

B. Single-mode fiber shall be used to connect the main cabinet and all distribution (and any other) cabinets throughout the station.

C. Single mode fiber shall be used for all communications purposes outside of the station facility.

D. All installed copper and fiber cable throughout the station shall be outdoor type. Unless rated as outdoor/indoor cable type, all outdoor cabling past 50 feet from the point of entrance into the facility shall be switched to the indoor type. All outdoor cabling containing metallic (conductive) elements shall be properly lightning/surge protected at the point of entrance into the facility or cabinets according to NEC and also requirements found within these Specifications.

E. Wire conductors shall be composed of soft or annealed copper, meeting insulating, and sensitivity and elongation requirements of ASTM B3. Joints made in conductors during manufacturing may be welded or brazed using silver alloy solder and non-acid flux.

F. The insulation shall be colored virgin propylene copolymer meeting the requirements of ASTM D4101, or equivalent, for propylene plastic. High molecular weight polyethylene is also acceptable.

G. All outside communication cables (those run in conduits or duct banks) shall be foam/skin insulated conductors that meet RUS Specification 7 CFR 1755.890 and shall be rodent protected.

H. Inside wire (wiring run within any building) from telephone terminals to telephone instruments shall be 22 AWG or 24 AWG and have a characteristic impedance of 105 ohms plus or minus 15 percent. Cable shall be low smoke, non-toxic, Teflon.

I. Communications cables shall be type and size (number of pairs) identified for the installation of the various communications systems.
J. Communications cables shall be UL Listed and Approved for intended use. All cable shall be of Type specified by the NEC for use in plenum, non-plenum, and riser spaces.

K. Communications cable suitable for use in ducts, plenum, and other space used for environmental air shall be UL Listed as being smoke resistant, shall be Teflon-coated and shall be classified as type CMP communications cable.

L. Communications cable suitable for use in vertical shafts shall be UL Listed for use in such space and shall be classified as type CMR communications cable.

2.02 UTP CAT 6 CABLE

A. Category 6 cable shall meet the following requirements:
   1. Polyethylene sheath
   2. Low smoke, rated for 90°C

B. All UTP CAT 6 connections shall comply with standards per TIA/EIA-568

2.03 UTP CAT 6 CABLE (AERIAL)

A. Aerial outside plant CAT 6 shall meet the following requirements:
   1. Polyethylene sheath
   2. Low smoke, rated for 90°C
   3. Suitable for aerial application

2.04 COAXIAL CABLE

A. Where required, provide coaxial cables for video transmission; 75 Ω characteristic impedance; double braided copper shield and a 20 AWG solid copper center conductor, manufactured for the intended purpose.

B. Types: RG6 and RG11. Do not use other types.

C. Where required, coaxial cable used for the CCTV system shall meet the following characteristics:
   1. Jacket: NEC CL2P Plenum Rated
   2. Wires: Uniquely Color Coded
   3. Shield: 1 overall foil shield, with a braided shield minimum
   4. Capacitance: $\equiv 53.2$ pF/M
   5. Resistance: $\leq 10$ ohms/100 M

C. At no time subject any coaxial cable to a bend of less than 6-inch radius.
2.05 RS-485/RS-422/RS-232D DATA CABLE

A. RS-485/RS-422/232D Data Communication Cable. If required, serial data cables used for RS-422, RS-485, or RS-232D balanced electrical transmission of data shall meet the following characteristics:

1. Jacket: NEC CL2P Plenum Rated, Low Smoke
2. Wires: Uniquely Color Coded
3. Cable Type: Twisted pair
4. Conductor gauge: 24 AWG (7 X 32 AWG) stranded, minimum
5. Shield: Individually foil shielded pairs each with a drain wire; and one overall foil shield, with a braid shield minimum
6. Capacitance: \( \leq 13 \text{ pf/ft} \) (12 pf/ft for RS-232D)
7. Resistance: \( \leq 16 \text{ ohms/1000 ft} \) (30 ohms/1000 ft for RS-232D)

2.06 FIBER OPTIC CABLE (ALL DIELECTRIC)

A. New outside plant (OSP) all dielectric single-mode fiber optic cable (FOC) shall be furnished and installed between the Communications Equipment Room (CER) and field Distribution Cabinets (DC) without intermediate distribution or cross-connects. Multi-mode cable can only be used as an exception and only if approved by the Engineer. Such cable shall be outside plant and all dielectric.

B. Dielectric single mode (and, if used, multi-mode) fiber optic cable shall be furnished. All fiber optic strands shall be terminated with SC-type connectors. All fiber strands shall appear at assigned demarcation panels, including spare (dark) fibers.

C. General: All outside plant FO cable shall be certified to meet applicable tests of TIA/EIA-455.

D. Construction:

1. Each fiber buffer tube will be color-coded so as to provide unique and permanently visible identification. Color coding shall be in accordance with TIA/EIA-598.
2. A dielectric strength member shall be central to the cable core.
3. The cable shall be designed for outdoor use and be waterproof, including water-proof tape and/or gel-filled.
4. The shipping length of cable shall be permanently identified by printing on the outer surface of the jacket, at intervals of 5 ft or less. Information is to include count of fibers, fiber type and size, cumulative footage markers, manufacturer's designation and manufacturer's name.
5. Design and construction shall recognize the nature of fiber optic cables regarding installation, especially at manholes. Allowance for such fiber characteristics shall be made in cable pull budgets.

E. Single-Mode Optical Fiber Characteristics:

1. Fiber Type: Class IVa Dispersion; Unshifted Single-mode fiber, compliant with TIA/EIA-492CAAB
2. Core Diameter: 8.3 microns (nominal)
3. Mode Field Diameter: 8.7 - 9.5 microns
4. Cable Cut-off Wavelength: < 1250 nm
5. Maximum Attenuation: 0.4 dB/km @ 1310 nm, 0.3 dB/km @ 1550 nm
6. Zero Dispersion Wavelength: 1300 - 1322 nm
7. Zero Dispersion Slope: < 0.095 ps/(nm2-km)
8. Gigabit Ethernet distance guarantee: 1,310/1,550 nm-5,000 meters

F. Cable Mechanical Specifications:

1. Nominal Jacket Wall Thickness: 0.055 in
2. Maximum Tensile Load Rating - Installation: 600 lbs
3. Maximum Tensile Load Rating - Maintained: 100 lbs

G. Maximum attenuation variation during operation (minus 40 degrees C to plus 65 degrees C), installation (minus 30 degrees C to plus 60 degrees C), and storage (minus 50 degrees C to plus 70 degrees C):

1. Multimode fibers: plus 0.50 dB/km at 1300 nm
2. Single-mode fibers: plus 0.20 dB/km at 1550 nm

H. Cable Markings:

1. Imprinted with white characters on the outer cable jacket
2. Permanent, insoluble in water and legible for the cable life
3. Imprint the following identification markings on the cable jacket at intervals of not more than one meter:
   a. Manufacturer
   b. Year of manufacture
   c. "OPTICAL CABLE"
   d. Manufacturer's part number
I. Fiber Connectors:
   1. Connectors shall be SC type
   2. Optical parameters of the connectors shall meet the requirements of TIA/EIA-568

2.07 AERIAL FIBER OPTIC CABLE

A. New outside plant (OSP) single mode gel-filled loose tube optical fiber cable shall be installed if the fiber is not in conduit.

B. Fiber optic cable shall be manufactured for aerial applications with a messenger wire.

C. The fiber optic cable shall comply with IEEE 802.3z.

D. General: All outside plant aerial FO cable shall be certified to meet applicable tests of TIA/EIA-455.

E. Construction:
   1. Each fiber buffer tube is color-coded to provide unique and permanently visible identification. Color-coding shall be in accordance with TIA-598.
   2. A dielectric strength member shall be central to the cable core.
   3. The cable shall be designed for outdoor use and be waterproof, including waterproof tape and/or gel-filled.
   4. Each shipping length of cable shall be permanently identified by printing on the outer surface of the jacket, at intervals of 5 ft or less. Information is to include count of fibers, fiber type and size, cumulative footage markers, manufacturer's designation and manufacturer's name.
   5. Central strength member shall be PE Covered Glass Reinforced Plastic.
   6. Messenger Wire: Flooded Stranded EHS Steel

F. Fiber Connectors:
   1. Connectors shall be SC type
   2. Optical parameters of the connectors shall meet the requirements of TIA/EIA-568

2.08 SINGLE-MODE FIBER OPTIC PATCH CORDS (FAN OUT ASSEMBLY)

A. General:
   1. Described as a pre-connectorized (one end only) single mode fiber optic pigtails, suitable for splicing distribution SM fiber strands to termination equipment.
2. Glass optical core fiber with a core cladding of low density glass concentric about the optical core, a protective acrylate buffer coating, and a PVC loose tube buffer to protect the outer surface of the fiber.

3. Tensile strength member: Aramid fiber applied over the buffered fiber followed by a PVC outer jacket.

4. Factory-terminated on one end with an SC-type fiber optic connector.

5. Field determined length for each patch cord, minimum 6 ft.

B. Optical Fiber Specifications
1. Buffer Diameter: 900 microns
2. Maximum Connector Insertion Loss: 0.5 dB
3. Connector Return Loss: < minus 55 dB

C. Patch Cord Mechanical Specifications
1. Nominal Cable Diameter: 0.12 in
2. Maximum Tensile Load Rating - Installation: > 100 lbs
3. Maximum Tensile Load Rating - Maintained: > 50 lbs
4. Minimum Bending Radius - Installation: < 2.0 in
5. Minimum Bending Radius - Maintained: < 1.5 in
6. Crush Resistance: > 400 lbs/in
7. Impact Resistance: > 1,000 cycles
8. Flex Resistance: > 7,500 cycles
9. Cable Length: 6.0 ft (minimum), or as determined by Contractor and approved by Engineer
10. Patch Cord Termination
11. One end of the fiber optic patch cord shall be factory-terminated with a SC-style connector with a strain relief boot with no terminations on the other end.
12. Ferrule Material: Zirconia Ceramic

2.09 PUBLIC ADDRESS SYSTEM CABLES
A. Audio Cable shall be utilized to connect the Public Address output amplifier with all platform and station speakers to meet the following characteristics:
1. Speaker Cable shall be two pair.

2. Shielded outdoor rated copper cable with outer shield drain wire.

3. Shields shall be terminated only at the cabinet.

4. Minimum of 16 AWG shall be used between speakers and cabinet termination. Minimum of 12 AWG shall be used between output amplifier and cabinet termination. If required by the PA load and voltage drop calculations, the Contractor may be required to utilize PA cabling of a bigger diameter than specified within this paragraph above.

5. Conducting wires shall contain minimum of 7X26 strands.

6. The design of the outer jacket shall correspond to indoor or outdoor types of applications.

B. Microphone cable shall be two pair 18 AWG stranded twisted pair with shield.

C. Local distribution cables for the PA system shall be placed in separate conduit or raceways from low-level voice and data circuits. Cable jacket shall have 600-volt rating.

2.10 T1 AND CATEGORY 6 DATA COMMUNICATIONS CABLE

A. The cable for connection of DSX-1 compatible signals shall be Western Electric ABAM or Engineer approved equal.

B. Cable jacket shall be low smoke and rated for the environment installed.

C. Wires will conform to PIC color code, type twisted pair, with conductor gauge solid annealed.

D. Each cable copper pair will be individually shielded with drain wire.

E. Characteristic impedance will be 100 ohms @ 772 khz, with mutual capacitance at 90 nf/mi.

F. Category 6, 4-pair data cable shall be solid conductor when used in horizontal distribution per TIA/EIA 568. Cable shall be stranded pair when used as patch cords for local equipment connectivity.

2.11 LABELS AND TAGGING

A. All labels, number plates and warning notices shall be of durable and corrosion resistant materials securely fitted by permanent means and clearly worded. For outdoor use they shall remain legible and not suffer degradation throughout the expected life of the equipment. Labels, number plates, and warning notices shall have black lettering on a white background.

B. Marking tags for wires and cables shall be permanent and non-conducting which securely fasten to wires and cables. Wrap-on tags are not acceptable.
1. **Sleeve Type Tags**: Tags for identification of individual cable conductors and field-installed wires within equipment cabinets shall be the sleeve type.

2. **Flat Plastic Tags**: Tags for identification of multi-pair or multi-conductor cables shall be the flat plastic laminated types.

3. Tags shall be one and one-half inches long by three-quarter inch wide with one, five-sixteenth inch hole located in the center of the width. The untreated tag shall be milk white "vinylite" or Engineer approved equal.

4. The identifying nomenclature space shall allow for three rows of lettering, and the tag material shall be capable of receiving typed-on characters by conventional means. The height of the lettering shall not be less than one-eighth inch.

5. Tags shall be the type that after lettering, both the face and back side of the tag shall be covered with a clear plastic coating, "vinylite", or Engineer approved equal.

### 2.12 SOURCE QUALITY CONTROL

A. Monitor the manufacturer(s) of the wire and cable to ensure 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 Engineer approved submittals.

B. Each finished wire and cable shall be traceable to the test date on file for each step in its manufacturing process.

C. **Factory Testing of Fiber Cables**:

1. Test each fiber optic cable strand on-reel prior to shipment and prior to placement on-site.

2. Record end to end loss for each fiber at 850/1300 nm for multimode and 1310/1550 nm for single mode.

3. Optical Time Domain Reflectometer (OTDR) with hardcopy record shall be provided for each fiber.

4. Test optical dispersion for each fiber.

5. Submit certified copies of tests results to the Engineer.

### PART 3 – EXECUTION

#### 3.01 INSTALLATION

A. Furnish and install all necessary junction boxes, pull boxes, connectors, ceiling wires, supports, cable and wire to provide a complete and reliable system. All equipment shall be properly protected from the exposure to the elements according to the manufacture recommendations and to ensure ease of future
maintenance. After installation, all such equipment shall be inspected by the Engineer to verify the Contractor installations meet the standards of the state of good maintenance.

B. Cable ends shall be resealed promptly when a length is cut from the reel. Cable reels shall be properly handled, i.e., by using a sling and spreader attached to a shaft through the reel hubs, or by cradling both flanges between lift truck forks. 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. Reels shall not be laid flat, and shall always be rolled in the direction opposite the cable wind on the reel.

C. Verify that the installation design is correct and adequate for the cables to be installed. Ensure that conduit size, conduit fill, conduit bend radii, manhole and pull box/junction box spacing, manhole and pull box/junction box size, raceways, ducts, and associated hardware are proper for the intended installation.

D. Verify the required cable length for each cable run prior to installation. Referenced 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.

E. Wires and cables shall be continuous without splices between junction boxes, terminals, pull boxes, manholes and hand holes. Cable shall not be bent to a radius less than the greater of 20 times the diameter of the cable or the manufacturers’ recommended minimum bending radius, during installation or as finally installed.

F. Install cable per the Engineer approved installation and cable plan. Provide any installation hardware necessary to route, support, terminate, or protect any cable installation.

G. Notify the Engineer 48 Hours notice prior to installing cables.

H. Installation shall conform to RUS TE&CM Parts 641 and 644, and TIA/EIA 568 and TIA/EIA-569 and to applicable sections of the NEC and the requirements as specified.

I. Where cables leave conduits, the end of the conduit shall be fitted with end bells/bushings to prevent damage to the cable.

J. Provide appropriate special protection for cables in areas where the cables are unavoidably exposed to hazardous conditions such as movement, vibration or sharp corners on equipment.

K. Wires and Cables in Conduit: Crossover of cables shall be avoided when cables are pulled into conduits. Care shall be taken not to have the conductors pulled tight or twisted in conduit fittings or boxes. Pull and install all cables to be installed in a single conduit simultaneously.

L. In order for unshielded twisted-pair cabling infrastructure to deliver high-speed performance, it is manufactured to very tight specifications. Consequently, to
maintain the unshielded twisted-pair cabling system performance proper installation practices shall be followed. At minimum follow the requirements listed below:

1. Do not crush the cable (by over cinching with cable ties or by using a staple gun). Use of Velcro cable ties in the rooms is required.

2. Do not kink, knot or snag the cable while pulling; this will cause damage under the jacket and may alter cable performance.

3. Do not exceed the recommended pulling tension. A break away swivel shall be used for fiber optic cable.

4. Per TIA/EIA 568, do not untwist the pairs of cable beyond the absolute minimum required for termination.

5. The cable jacket on UTP shall only be stripped back the minimum required per TIA/EIA 568 to terminate to connecting hardware.

6. Maximum cable lengths shall not be exceeded. (295 feet for UTP horizontal runs or 328 feet for UTP channel).

7. Properly rated patch cables will be provided and tested, from patch panels to equipment and from port to port for fiber patch panels, to provide continuity from end to end. Channel testing, inclusive of patch cords, will be in accordance with TIA/EIA 568.

8. Per the NEC, a 40 percent fill ratio for all conduit runs is recommended for conduits with more than 2 cables.

9. All fiber optic cables shall be set in inner-duct with an appropriate flame and smoke rating equal or better to the cables being housed.

10. SC type connectors for fiber are recommended by TIA/EIA 568 (orange for multi-mode and yellow for single mode).

M. Use no oil, grease, or similar substances to facilitate the pulling in of conductors. Use a specifically approved wire pulling compound.

N. Pull in no wire or cable until all construction which might damage insulation or fill conduit with foreign material is completed.

O. Pull wire into conduits with care and prevent damage to insulation. Use basket-pulling grips to avoid slipping of insulation on conductors. Nylon, polypropylene or hemp rope, or other "soft" surfaced cable must be used for pulling in conduit other than steel.

P. Do not use blocks, tackle, or other mechanical means to pull wires No. 8 AWG, or smaller.

Q. For wire/cable runs above suspended ceilings, which are not in conduit, clamp cable to underside of deck or use wire hangers; do not allow it to lie on top of
the ceiling panels. In open ceiling areas, clamp cable to underside of deck in pan troughs or along beams to aid concealment.

R. Support wire and cable in all equipment, all terminal cabinets and in all terminals and pull boxes in vertical risers and horizontal runs. Use wire duct and strap-type supports. Furnish and install appropriate wire duct at all locations where wire duct is required for good wire management, whether shown on elevations or not. Where terminal boards are used, furnish and install wire duct on both sides. At no time shall wires cross over terminal boards. Arrange cables neatly to allow inspection, removal, and replacement.

S. Provide grommets and strain relief material where necessary to avoid abrasion of wire and excess tension on wire and cable.

T. Comb wire groups. Route and support wiring and cable to achieve the highest quality appearance in all areas, including the interior of all panels and racks.

U. Make no splices in cables. Cables shall be continuous between all designed termination points.

3.02 TERMINATIONS

A. Copper Cable:

1. Cables shall be trained into final position while observing minimum bending radii. Provide slack at all terminals in an amount sufficient for three re-terminations.

2. Wire and cables where connected directly to equipment shall be of sufficient length to allow access for removal and inspection of equipment without having to disconnect. 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. Connectors shall be fitted with retentive dust caps.

4. For stranded copper wire, compression-type, insulated terminals in accordance with the wire and cable manufacturers' recommendations shall be used. The terminals shall be installed only with tools and techniques recommended by the terminal manufacturer. Solid wire shall be terminated by wire eyes. IDC-type termination blocks will be used only with solid conductors.

5. Wires and cables shall be terminated at protected terminal blocks. 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 torque to the rated value of the nut.

6. All audio cables entering cabinets or facilities shall be protected with protection equipment specifically design for such application.
7. Protected Terminal Blocks shall be DIN rail mounted and grounded to the corresponding facility or cabinet communications ground bus.

B. Fiber:

1. Slack in Fiber Distribution Panel (FDP) shall be restrained and shall be sufficient for strain relief per TIA/EIA 568.

2. Attach the central strength member of cable to the FDP. Attach the outer jacket of the cable to the FDP with a cable clamp.

3. Run fiber optic cable inside buildings in protective inner-duct. Inner-duct shall extend into the FDP for continuous cable protection and identification.

4. Fiber optic splices shall be fusion splices. Fusion splicing shall be performed by qualified personnel utilizing splicing equipment with Local Injection and Detection (LID) to optimize splices. The loss across each spliced fiber shall be less than or equal to 0.04 dB.

3.03 CABLE TIES

A. Sized appropriately and rated to the installation conditions. Plenum rated cable ties will be used where any cable supported is rated CMP.

B. Install at 4-foot maximum intervals, roughly centered between hangers, and at other appropriate locations to keep the wire groups neat. Ensure the cable ties do not cause cables to exceed with the minimum bend radius requirement.

3.04 IDENTIFICATION TAGS FOR CABLES, WIRES AND EQUIPMENT

A. Tag all wires and cables during the termination process, as specified herein. Tagging formats and administrative records shall be maintained for all cables in accordance with TIA/EIA-606. Labels shall be concise and preferably diagrammatic in form.

B. Identify all conductor wires and cables whenever they enter or leave a junction box, manhole, housing, or enclosure, and at all terminals.

C. Securely fasten marking tags to the wires and cables for identification. Place tags prior to termination.

D. Wire designations shall consistently conform to an overall scheme approved by the Engineer to indicate location, circuit, device, wire number, terminal branch, and position, etc. Use letters and numbers.

E. Cables and Wires:

1. A unique identifier shall be assigned to, and marked on each cable to serve as a link to the cable record. Both ends of each cable and each cable wire and all single wires that terminate in equipment cabinets, equipment terminal blocks, punch down blocks and computers shall be permanently identified with a tag. Tags shall not obscure connection
links used between terminal binding posts. Tags shall be installed so that they may be read with a minimum of disturbance of the tags. Tags will be placed not greater than 2 inches from the point of wire or cable termination.

2. Tag Installation: Install tags and apply conductor nomenclature in accordance with the manufacturer's instructions. Installation shall result in a permanently bonded and legible identification.

3. Spare wires for future use shall be labeled, with exposed ends taped.

F. Post cable schedule and identification key on each equipment rack and cabinet door for future reference.

3.05 FIELD QUALITY CONTROL

A. Refer to Section 01545, Work Site Safety and Security, and General Conditions and Special Conditions in regard to safety in proximity to the operating system.

B. Follow approved cable testing plan.

C. Provide all instruments, materials and labor required for tests specified.

D. Notify the Engineer of testing schedule for the purpose of witnessing complete testing on all cable installations.

E. Follow test equipment manufacturer's instructions as to operation and electrical connections.

F. Testing Copper Cables:

1. The test plan shall include the insulation resistance and continuity tests. The test plan will conform to RUS Specification 7 CFR 1755 Bulletin 1753F-201 (PC-4) for multi-pair cable. Category 6 level data cables shall be tested and certified per TIA/EIA 568.

2. All associated communications equipment not under test shall be disconnected and grounded. All electronic devices or signal equipment shall be disconnected or unplugged prior to any testing. All cable splices shall have been completed.

3. After installation of the entire length of a cable, perform the tests listed below on each cable. To preclude damage to equipment and devices, conduct the tests before the cable is terminated at the electrical equipment. If termination has been made, disconnect cables from the equipment for testing and reconnect after completion of tests.

4. Dielectric Test: Perform test to ensure that the cable insulation has not been impaired during installation.

5. Continuity Test: Perform test to prove the continuity of the conductor. The test shall be made of all conductors and shields.
6. Insulation Resistance Test: Perform test to determine the conductor to ground resistance and conductor to conductor resistance. Conduct tests with a 500V motor-driven megger. Apply test voltage between the conductor and ground and hold until the reading reaches a constant value for five minutes. Insulation resistance values obtained by the megger tests shall not be less than two mega-ohms. Bring to the Engineer’s attention the results of similar tests having unequal readings with the variations of 25 percent or more.

7. Perform end-to-end tests on all cables where cables enter or leave cases, communication houses or other facilities.

8. For each test, record all data on approved test forms.

9. Replace with new cable any installed cable found defective during testing.

G. Testing Fiber Cables: Refer to Source Quality Control herein for factory testing. Perform the following installed tests after installation is complete.

1. Notify the Engineer 24 hours in advance of testing.

2. Record optical link attenuation from FDP to FDP. Record optical channel attenuation from FDP to each Distribution inclusive of optical patch cords and connections passing through multiple links (Distribution and patch panels) per TIA/EIA 568-B.3.

3. Submit OTDR records including hardcopy and CD softcopy, for both directions of transmission, to the Engineer.

4. Test all fibers:
   a. OTDR tests shall be performed such that the FDP and patch panel terminations and jumpers shall be shown.
   b. The loss across each connector and splice shall be shown. There shall be no single point loss on a fiber greater than 0.1 dB per TIA/EIA 568.

H. For fiber optic cable, complete on-site baseline OTDR testing and submit test reports prior to cutover.

I. For UTP CAT 6 cable, complete manufacturer recommended testing and submit test reports prior to cutover.

END OF SECTION
SECTION 17160
OUTDOOR COMMUNICATIONS CABINETS

PART 1 - GENERAL

1.01 DESCRIPTION
A. Section describes requirements for outdoor communications cabinets associated with station networks and subsystems, including design of cabinets.

1.02 GENERAL
A. Typical Station Communication design involves two major equipment housing locations. They are:

1. Communications Equipment Room (CER) which may be a prefabricated shelter or house or may be an environmentally and access controlled space within the station building structure. This space houses the main communications equipment with direct access to the carrier network. The equipment cabinets used in the CER are described in Section 17050, Basic Communications Equipment, Materials, and Methods.

2. Distribution Cabinets (DC) are outdoor rated enclosures located throughout the station, which house network equipment for direct subsystem connectivity. Main requirements for the Distribution cabinets are included within this section. Section 17050, Basic Communications Equipment, Materials, and Methods provides for additional requirements for the Distribution cabinets.

B. Non-typical Station Communication design may include the following types of equipment locations as specified in this Section:

1. Communications Interface Cabinet (CIC) is an outdoor rated cabinet to house the main communications cabinet. A CIC is also sometimes referred to as a Station Communications Cabinet (SCC). In this Section the term 'CIC' will be used further on. CIC is used for temporary station construction and in lieu of other environmentally and access controlled space such as the CER. This cabinet shall be rated for outdoor use and be the large enough to house all the station or facility main communications equipment.

2. Field Communications Cabinet (CC) is a small outdoor rated enclosure capable of housing subsystem network components and cable terminations. Unlike a Distribution Cabinet (DC), CC is used at a subsystem device where standard distribution topology is not possible. CCTV camera located greater than 328 feet from the nearest DC is an example of when a CC at the subsystem device shall be used.
1.03 REFERENCE STANDARDS

A. ASTM International (ASTM):
   1. B3 Specification for Soft Annealed Copper Wire

B. National Fire Protection Association (NFPA):
   1. 70 National Electric Code
   2. 130 Fixed Guideway Transit and Passenger Rail Systems

C. National Electrical Manufacturers Association (NEMA):
   1. 250 Enclosures for Electrical Equipment (1000 Volts Maximum)
   2. ICS-1 General Standards for Industrial Control and Systems
   3. ICS-4 Terminal Blocks
   4. ICS-6 Industrial Controls and Systems Enclosures
   5. FB1 Fittings, Cast Metal Boxes and Conduit Bodies for Conduit and Cable Assemblies
   6. VE1 Metallic Cable Tray Systems
   7. WC 7 Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
   8. WD 1 General Requirements for Wiring Devices

D. California Electric Code (CEC)

E. National Electrical Contractors Association (NECA):

F. Telecommunications Industry Association (TIA):
   1. TIA/EIA-568-B.1-2 Commercial – Building Telecommunication Cabling Standard
   2. TIA/EIA-J-STD-607 Commercial – Building Grounding and Bonding Requirements for Telecommunications

G. Underwriters Laboratories, Inc. (UL):
   1. 50 Enclosures for Electrical Equipment – Nonenvironmental Considerations
   2. 50E Enclosures for Electrical Equipment – Environmental Considerations
3. 497 Protectors for Paired Conductor Communication Circuits

4. 508 Industrial Control Equipment

5. 514A Metallic Outlet Boxes

6. 514B Conduits, Tubing and Cable Fittings

7. 969 Marking and Labeling Systems

8. 1059 Terminal Blocks

1.04 SYSTEM DESCRIPTION

A. Provide the type of outdoor communications cabinets indicated in the Contract Documents.

B. Provide and mount the following equipment inside the Communications Cabinet (CC) per the Contract Drawings. Depending on the type of cable connectivity (copper or fiber), the following equipment shall be included:

1. Fiber or copper cable termination panel

2. Fiber or copper media converter(s)/switch(es)

3. DC power supply if applicable

4. Terminal or protection blocks (copper cabling and/or any outdoor cabling with conductive materials)

5. UPS and general purpose ac receptacles

6. Grounding Equipment

C. Provide and mount the following equipment inside the Communications Interface Cabinet (CIC) as associated with the station's main network communications. Include the station communication network interfaces which connect the station to the OCC via leased or owned network transport facilities:

1. Fiber termination and splice panels

2. Audio switch/amplifier/controller/microphone(s) for PAS

3. UPS power supply and distribution

4. Network Data Switches, CSU, or channel banks

5. Clipper CID Equipment

6. Phone Equipment

7. Terminal or protection blocks for MPOE and any outdoor cabling with conductive materials
8. Cable Management equipment
9. Grounding Equipment

D. Provide and mount the following equipment inside the Distribution Cabinet (DC) as associated with the stations main network communications:

1. Fiber termination and splice panels
2. UPS power supply (where required) and distribution
3. Network Data Switches, CSU, or channel banks
4. Clipper CID Equipment
5. CID Power Supplies
6. Terminal or protection blocks for any outdoor cabling with conductive materials
7. Cable Management equipment
8. Grounding Equipment

E. Provide termination and electrical protection for all copper power, indication, control, audio, and communications cables that enter the CC, DC and CIC (where applicable).

F. Provide Heating, Ventilation and Air Conditioning (HVAC) to maintain the temperature as specified in this Specification, under the ambient conditions specified in this Section (as required by each cabinet’s design thermo calculations approved by the Engineer).

1.05 SUBMITTALS

A. Refer to Section 17000, Basic Communications Technical Requirements, for related and additional submittal requirements.

B. Preliminary Design Technical Requirements: Include the following information as part of the Preliminary Design subsystem package for the DC, CC and CIC:

1. Drawings showing the communications cabinet dimensions, layout (plan and elevations).

2. All calculations including heating/cooling (thermo calculations) and power requirements. Thermo calculations shall show that the equipment mounted inside the cabinet for will operate without overheating and within their vendor-specified operational environmental range for ambient conditions specified in these Specifications. Submit seismic calculations to show compliance with the requirements of these specifications.
3. Equipment arrangement (including dimensions), for all equipment racks or surface mounted equipment and weight of equipment and major components.

4. Cable and conduit Entrance/Exit details including ID (tagging).

5. Grounding arrangement.

6. UPS and general purpose AC receptacle location and amperage.

7. Product specifications for HVAC equipment (where required), intrusion device, MDF, wiring blocks and circuit protection.

8. External Interface Details for Power Connections.

9. Door arrangement.

10. Mounting locations and supports for equipment mounted in the cabinets and/or enclosures.

11. Drawings showing space available for conduit entrance, knockout locations for routing and training of cables. Available space shall take into consideration bending radius requirements of cables.

12. Control schematics and relay logic with full narrative description of the control logic with reference to the device, relays, timers, contacts and components to be used for fabrication and installation.

13. Complete internal wiring diagrams.

14. Terminal strip designations.

15. Wire numbers.


17. Layouts and templates if anchoring in concrete (if required).

C. Final Design Technical Requirements: Include the following information as part of the FDR submittal package for the DC, CC and CIC:

1. Updated PDR information. All drawings, calculations and design information shall reflect a final design.

2. Final and detailed wiring drawings ready for construction and installation.

3. Final equipment list.

4. Final equipment installation details.

5. Final cable and equipment ID.
D. Installation Work Plans: Submit the following installation document for each site prior to the scheduled installation activity in accordance with these Specifications. The installation Work plan shall include the following:

1. Drawings showing plan and elevation details of the foundation and the duct bank, including the interface with the manhole.

2. Site plan information shall include specific layout (plan and elevation) and detailed grounding drawings for each DC, CC and CIC.

3. Delivery and Installation Procedures and Inspection Sheets:
   a. The procedures submitted shall include descriptions of the equipment used for transport and setting of the DC, CC and CIC, and shall include specific dates for installation.
   b. Inspection Sheets shall be completed and submitted to the Engineer after installation of the DC, CC and CIC. The report shall include details of cable terminations and equipment wiring diagrams marked-up with as-wired conditions.
   c. The installation drawings and procedures shall define the installation adequately and in sufficient detail, such that if the procedures are followed, the resulting installation shall meet approved standards, practices and procedures for workmanship, maintainability requirements, referenced installation standards and installation requirements defined within these Specifications and the Contract Drawings, and the installation requirements of local jurisdictions. If not, the installation drawings and procedures shall be revised prior to subsequent installations.
   d. The installation drawings and procedures shall adequately provide for the safety of installation personnel. If not, the installation procedures shall be revised prior to subsequent installations.

E. Calculations and Certifications:

1. Calculations as listed in the Final Design.

2. ISO certification for all proposed manufacturers.

F. Product Samples: Submit and demonstrate product samples when required by these specifications

G. Test Plan and Procedures: In accordance with the format and requirements described in these Specifications, as a minimum, submit the following plan and procedures to satisfy the CC or CIC testing requirements:

1. Test program plan: Include all the required information for the DC, CC and CIC in the Test Program Plan as outlined in these Specifications.
2. Factory and Inspection Test Procedure: Submit a complete factory test and inspection procedure to satisfy all the requirements outlined in paragraph 3.02 of this Section.

3. Field Test Procedure: Submit a complete field test procedure to satisfy all the requirements outlined in paragraph 3.02 of this Section.

4. End-To-End Acceptance Test: Where used, conduct end-to-end testing of cabinets’ intrusion alarms.

5. System Integration Test: Provide qualified staff to support this test as described in Article entitled Testing and Inspection herein.

H. Test Records: Submit the Inspection and Test Records and Results for review after the completion of each test, in accordance with format described in these Specifications.

I. Manufacturer Qualifications: Submit qualifications for any manufacturer differing from those specified herein and obtain Engineer’s prequalification and approval. Acceptability of the manufacturer shall be based on the manufacturer’s experience, qualifications, certifications (i.e. ISO-9001), equipment reliability, and compliance with standards specified herein, and full compatibility with Caltrain’s existing systems.

J. As-Built Documentation: Submit complete As-Built documentation and drawings, O&M and other manuals, as specified in Section 17000, Basic Communications Technical Requirements, for each DC, CC and CIC and contents.

1.06 QUALITY ASSURANCE

A. Applicable Standards and Codes:

1. Fabrication, inspection, installation and testing shall comply with all applicable Standards and Codes as listed herein.

2. All equipment and methods shall comply with the latest version of the standards.

B. Material and Workmanship Requirements:

1. All equipment provided under this Section shall be UL listed.

2. All grounding shall be in accordance with these Specifications, and with the recommendations of the equipment manufacturer.

3. Use no discontinued product models, refurbished equipment, products at their end-of-life, end-of-sale, or end-of-service.

4. All products specified herein shall be subject to the Engineer approval based on the Contractor’s ability to demonstrate adherence to the specified requirement and approval of the manufacturer’s quality process (i.e. ISO-9001).
PART 2 - PRODUCTS

2.01 GENERAL DESIGN REQUIREMENTS

A. Physical Characteristics:

1. The DC, CC or CIC shall be a custom enclosure.

2. Rated NEMA 4X and vandal-proof. Where HVAC is required (as the result of thermo calculations), it is acceptable to manufacture cutouts for mounting of air conditioning and fan heat exchange equipment, which will downgrade the initial rating of the outdoor cabinet from NEMA 4X to NEMA 3R. To maintain protection of the cabinet and its equipment against water, moisture and other elements, use the heat exchange equipment vendor recommendations regarding types of gaskets and other methods required to seal any potential openings as a result of installation of such equipment on the side of the outdoor enclosures. The Engineer can consider acceptance of use of enclosures with initial NEMA 3R rating as long as they provide for the same corrosion and vandal-proof protection as described in this paragraph above.

3. Minimum dimensions: Minimum cabinets’ dimensions below shall be adjusted to accommodate the actual project equipment and shall also account for 50% of spare space (for future growth):

   a. CIC shall be 72 inches (Wide) x 96 inches (High) x 36 inches (Deep)
   b. CC shall be 20 inches (Wide) x 24 inches (High) x 8 inches (Deep)
   c. DC shall be 24 inches (Wide) x 48 inches (High) x 30 inches (Deep)

4. As (and if) required by the thermo-calculations (calculated equipment BTU load), the cabinets shall be equipped with a ICE QUBE IQ8000VHA, IQ10000V or IQ12000V air conditioner/heater or Engineer approved equal. To ensure the HVAC units are vandal proof and to protect fan openings and outside controls, the units above shall be equipped with the appropriate additional protective equipment such as Washdown Hoods, Remote Controllers, etc.

5. The CIC shall have two doors on the front side and two doors on the rear side.

6. The DC shall have a front side door and a back side door.

7. Doors shall provide seal via foam-in-place gasket, and shall be hinged and equipped with a 3-point lockable handle.

8. DC, CC and CIC shall be fabricated from 12-gauge stainless steel.

9. MDF shall be provided within the CIC for cable termination and circuit protection in accordance with these Specifications, and the Contract Drawings.
10. FDP shall be provided with a maximum of 72 connections for termination of single-mode fiber cables. Refer to Section 17250.

11. Lexan Polycarbonate panels, ¾” thick, painted white in accordance with this Section, shall be provided for mounting manual disconnect switches, MDF, and cross-connect terminal block.

12. The Contractor shall install standard EIA-310D racks in the DC and CIC. Racks shall be zinc-plated steel and located so that equipment does not interfere with cable path to the MDF. Blank panels shall be provided and installed in locations where equipment is not present; as depicted in the Contract Drawings.

13. Where access to rack-mounted equipment is not convenient from either the front or rear, a zinc-plated steel pullout shelf shall be provided for that equipment.

14. A zinc plated steel pull out shelf shall be provided for supporting a local VMB input device.

15. UPS support hardware shall be provided.

16. A UL approved rack-mounted power strip and light bulb holder (with light bulbs) shall be provided for each door side of the DC and CIC. The light bulbs shall be protected with a heavy duty wire cage.

17. All cables routed within the DCs or CIC shall be organized and routed in conduit or flex tube for cable protection. The cabinets shall utilize the appropriate cable management hardware.

18. The inside cabinet (DCs and CIC) floor shall be at least 6 inches above the concrete pad on which the cabinet is located.

19. Power line filter shall be provided for improvement in processor immunity to high frequency noise. Ferrite sleeve shall also be provided for incoming AC power cable to reduce electromagnetic field interference.

B. Painting: Internal DC and CIC members (such as racks, cable tray, panels) that are not stainless steel shall be painted black with corrosion inhibiting paint. Refer to Section 17050, Basic Communications Equipment, Materials, and Methods, for product descriptions.

2.02 HVAC

A. Where required by thermo-calculations, a DC or CIC shall be equipped with a thermostatically controlled heater, sized to maintain the cabinet’s internal temperature above 50 degrees F with ambient temperatures as specified in these Specifications.

B. The HVAC unit shall be sized to provide 50% more cooling capacity than initially required by the installed equipment.
C. Cabinets shall be equipped with an air conditioner, which shall provide cooling when the internal temperature rises above 85 degrees F. The cooling device shall be sufficient to maintain cabinet temperature below 100 degrees F, with ambient conditions as specified in these Specifications. The air conditioner condensation drain tube shall be installed. It is acceptable for cabinets to operate at higher temperatures, as long as the Contractor-chosen equipment is specifically manufactured for such high temperature operations. For such equipment, the Engineer can consider Contractor exclusion of HVAC equipment (or downgrade cooling to use of fans only), if the Contractor can demonstrate with thermo calculations (including 50% future spare capacity) that equipment inside the cabinets will operate within its operational environmental parameters for the ambient temperatures as specified in these Specifications.

D. Any vents shall include vandal resistant 12-gauge wire mesh screens and rain hoods (wash down) designed to prevent vandalism and prevent horizontally driven windblown rain from entering the cabinet.

E. The HVAC temperature controller shall provide an adjustable high/low temperature alarm. Alarm contacts shall be hardwired to the MDF for monitoring.

F. To prevent vandalism, the temperature controllers shall be implemented inside the cabinet. If necessary, a remote controller option shall be used.

G. The HVAC system shall be optionally equipped with remote control via Ethernet with the approval of the Engineer.

2.03 CABLE ENTRANCES

A. CIC and DC concrete base shall be sealed with fire stop in accordance with these Specifications including around the conduits where they leave the base to stop moisture and fire.

B. The conduit/CIC/DC joint shall be completely sealed where the conduit penetrates the cabinet bottom. After all cables have been installed, conduits openings shall be filled with duct sealant in order to stop moisture and fire.

2.04 VANDAL PROTECTION AND SECURITY

A. Steel plates shall be installed as backing to the lockset or hasp.

B. Provide locks for each DC, CC and CIC so as to secure the entire cabinet. The locks shall have locking cylinders that match those used for other cabinets used in the Caltrain’s existing systems. Two keys shall be provided to the Engineer for each cabinet prior to project closeout.

C. An exterior skirt located at the bottom of the DC/CIC between the cabinet floor and the concrete pad shall be provided. The skirt shall be attached with vandal resistant stainless steel fasteners, and be designed to prevent trash from blowing or being forced under the cabinet.

D. The HVAC system shall be secured against easy access with ordinary tools.
**2.05 GROUNDING**

A. CIC and DCs shall be equipped with two copper grounding buss bars (for Chassis and Telecommunications grounding) as specified in these Specifications. Buss bars shall be located in the bottom of the cabinet and be mounted on insulators that electrically isolate the cabinet from the buss bars (see Contract Drawings).

B. The grounding buss bars shall each be bonded to a No. 4 AWG copper conductor, which shall be connected to a single point ground grid per Contract Drawings.

C. CIC and DCs shall be equipped with a 3/8-inch high tensile strength bronze stud, which shall be connected to the chassis grounding buss bar using a No. 6 AWG conductor per Contract Drawings.

D. Internal chassis grounding arrangement shall utilize No. 6 AWG insulated, stranded ground wire connected to the Cabinet Grounding Buss Bar (CGB) per site specific drawings.

E. Ground wire from the station AC supply panel shall be grounded to the CGB using No. 6 AWG ground wire per site specific drawings.

F. Protected Terminal Block ground shall be connected to the CGB using No. 6 AWG Ground wire per site specific drawings.

G. All electronic equipment signal and telecommunications grounds shall be grounded, using No. 6 AWG insulated stranded copper conductors, to the Telecommunications Main Grounding Buss Bar (TMGB) per Contract Drawings.

H. Shields from signal cables shall be grounded to the TGB in accordance and the Contract Drawings.

I. Grounding not described above shall be in accordance with these Specifications.

**2.06 TERMINAL BLOCKS**

A. Terminal blocks and Protected Terminal Blocks (PTBs) shall be as specified in these Specifications.

B. Terminal block and PTB types and pair counts shall be in accordance with the Contract Drawings.

C. The Protected Terminal Block shall provide protection of all communications cables outside the Station and Distribution cabinets against accidental and natural power surges.

**2.07 CIC AND DC CABINET LIGHTS AND INTRUSION ALARM**

A. Provide an interior cabinet light on each side of the CIC or DC enclosure. Each light shall turn on when the corresponding door is opened and turn off when it is closed.
B. Provide a simple intrusion detection circuit that shall utilize magnetic switches and be activated when any panel door is opened. Dual dry alarm contacts shall be wired to the MDF, cross-connected and terminated at the Communications Remote Terminal Unit (RTU), and reported to the Central Control Facility (CCF) via the Communications Transmission Subsystem (CTS) and UPS Dry Contact Alarm sensing (or, in the future, via Supervisory Control System (SCS)).

2.08 SOURCE QUALITY CONTROL

A. Notify the Engineer at least 21 days prior to these inspections.

B. Perform a pre-installation inspection for defects and verify that the DC, CC and CIC shall physically and dimensionally support the DC, CC and CIC equipment. This inspection shall take place before the DC, CC and CIC leaves the factory.

C. Factory Test and Inspection: Provide the Engineer with each test or inspection report after each test or inspection.

1. Inspect the DC, CC and CIC at the Factory for cracks and other damage, and repair as required.

2. Inspect the DC, CC and CIC at the Factory for level and plumb, proper operation of doors and locks, proper location and installation of HVAC equipment, and other miscellaneous equipment if applicable.

3. Inspections shall verify:

   a. Conformance to standards, methods, and quality.
   b. Correct location, positioning, seating, mounting, orientation, and labeling.
   c. Secured internal cable and wire connections.
   d. Proper routing and termination of internal wire and cable.
   e. Proper grounding of all equipment.
   f. Correct and complete labeling and tagging of wire, cable, terminal, connectors and equipment.
   g. Conformance to installation requirements.
   h. Conformance to inventory data.

4. Provide inspection results for the Engineer approval.

PART 3 - EXECUTION

3.01 INSTALLATION

A. DC, CC and CIC shall be installed at locations in stations as indicated on the Contract Drawings.
B. DC and CIC Mounting:

1. Prior to mounting the cabinet, verify that the cabinet foundation, conduit stub-ups and anchors are correctly configured as per the Contract Drawings.

2. Install the cabinet level and plumb on the cabinet manufacturer’s provided support feet. Verify that all parts of the cabinet (including open doors) are outside the dynamic envelope of the trains.

3. Plants, foliage, or other impediments shall be placed at least eight feet away from the installed cabinet.

4. Provide a 3-foot wide concrete foundation for the CIC and DC or as shown in the Contract Drawings.

5. After all cables have been installed and terminated, fill the conduit openings with an approved fire stop duct sealant to prevent fire and moisture from entering the cabinet.

6. Seal the bottom of the cabinet, where the conduits penetrate, with an approved sealant to stop fire and moisture.

7. Remove any auxiliary temporary equipment used for assistance of cabinet’s installation.

C. Cable Termination: Cables shall be dressed, tagged and terminated in accordance with these Specifications.

D. All grounding and cable wiring shall be field installed, labeled, and tested for continuity.

E. All equipment shall be installed according to Contract Drawings and manufacturer’s requirements.

F. Terminal blocks, PTB’s and cross-connects shall be mounted to internal panels and shall be arranged as shown on the approved site specific drawings. Equipment layout and mounting shall be done such that Terminal block, and PTB equipment shall not be impeded or obstructed by other equipment and shall allow technicians to make moves, adds, and changes with ease.

G. Contractor shall make all DC, CC and CIC equipment and MDF/terminal block connections, including all cross-connections, as shown on the Contract Drawings.

H. All connections and cross-connections shall use required wire in accordance with these Specifications, and the Contract Drawings.

I. DC, CIC and CC ac power shall be conditioned by UPS, capable of maintaining backup power to all AC powered CIC and CC equipment, for no less than 90 minutes under full load of all connected devices. Refer to Section 17460.

J. Power strips with no less than eight receptacles shall be installed in each rack within the CIC to provide UPS power to rack-mounted equipment.
K. Power strips shall be installed in accordance with Contract Drawings and oriented to provide the highest density of receptacles to the rear of rack-mounted equipment.

L. Install a clear plastic document pouch attached to the inside door frame containing a detailed parts list inventory of all equipment contained in the CIC or CC, and also include as-built drawings or diagrams showing equipment interconnections, wiring, power connections, and equipment configurations.

M. Once installation is complete remove any disposable installation materials including empty equipment containers, wrappers, wire fragments, or other items and thoroughly clean enclosure of dirt, dust, and all other contaminants.

3.02 TESTING AND INSPECTION

A. Inspect the DC, CC and CIC for defects after it is installed in the field. This inspection shall verify proper installation and sealing of the DC, CC and CIC, and also ensure that there are no sharp edges that could pose a hazard to the public or the Engineer personnel.

B. Check that all cables and wires are properly terminated and the terminations are correctly labeled.

C. Perform the following inspections and tests on each DC, CC and CIC, where applicable. The Engineer shall be given written notification prior to each test and inspection.

D. Provide testing and inspection submittals prior to each scheduled work for Engineer approval.

E. Provide the Engineer with each test or inspection report after each test or inspection.

1. Factory Test and Inspection: Refer to Source Quality Control herein

2. Field Inspection:
   a. Prior to installation, inspect the CIC and DC foundation, conduit stub-ups and anchors to verify that they conform to the Contract Drawings. Correct discrepancies prior to commencing cabinet installation.
   b. Field inspection shall include inspection of the CIC and DC including lighting fixtures, intrusion sensors, equipment racks.
   c. The inspection of the DC, CC and CIC installation shall confirm that:
      i. Conformance to installation requirements
      ii. Conformance to standards, methods and quality
      iii. Proper routing and termination of wire and cable
iv. Secured cable and wire connections

v. Proper grounding of all equipment

vi. Correct and complete labeling and tagging of wire, cable, terminal, connectors and equipment

3. Field Tests and Records: Perform the following field tests:
   a. Test the electrical continuity of the connections within the DC, CC and CIC by measuring the resistance from the line side to the equipment side for each conductor terminated within the cabinet.
   b. Verify operation of main circuit breaker and all feeder circuit breakers.
   c. Measure resistance to ground from all ground points, including those located in equipment cabinets. Measured resistance shall not exceed 3 ohms. Refer to Section 17060, Grounding of Communications Equipment.
   d. Verify operation of all lighting.
   e. Verify operation of HVAC equipment, including heaters, air conditioner, and all thermostatic controls.
   f. Verify operation and reporting of all CIC and DC alarm indications both locally and at the UPS Alarm Dry Contact (or future Communications RTU) terminal block.
   g. Verify operation of all equipment controls and indicators.
   h. Verify that all cables and wires are labeled properly and all color codes have been observed.
   i. Correct malfunctioning components on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
   j. Provide records of all electrical tests for Engineer approval.

4. End-To-End Acceptance test: End-To-End testing shall be a part of other subsystem testing.

5. System Integration Test: Provide qualified technical staff to perform this test.

END OF SECTION
SECTION 17250
FIBER OPTIC CABLE DISTRIBUTION SUBSYSTEM

PART 1- GENERAL

1.01 DESCRIPTION
A. Section includes requirements for fiber optic cable and associated passive components to provide a complete fiber optic structured cable system for station communications
B. Active components such as media converters and network switches are specified in Sections related to individual station communications subsystems.

1.02 REFERENCE STANDARDS
A. American National Standards Institute (ANSI):
   1. ICEA S-87-640 Fiber Optic Outside Plant Communications Cable
   2. TIA-455-177, FOTP-177 Optical Fibers Part 1-43: Measurement Methods and Test Procedures - Numerical Aperture
B. ASTM International (ASTM):
   1. D1248 Specification for Polyethylene Plastic Extrusion Material for Wire and Cable
   2. E814 Test Method for Fire Test of Through - Penetration Fire Stop
   1. 7CFR1755.900 RUS Specification for Filled Fiber Optic Cables
D. Telecommunications Industry Association (TIA)/ Electronics Industries Alliance (EIA):
   1. TIA/EIA 455 Standard Test Procedure for Fiber Optic Fiber Cables, Transducers, Sensors. Connecting and Terminating Devices and other Fiber Optic Components
   2. TIA/EIA 455-3, FOTP-3 Procedure to Measure Temperature Cycling Effects on Optical Fibers, Optical Cable, and Other Passive Fiber Optic Components
   3. TIA 455-13, FOTP-13 Visual and Mechanical Inspection of Fiber Optic Components, Devices, and Assemblies
4. TIA/EIA 455-25, FOTP-25  Impact Testing of Fiber Optic Cables and Cable Assemblies
5. TIA 455-33, FOTP-33-B  Optical Fiber Cable Tensile Loading and Bending Test
6. TIA/EIA 455-37, FOTP-37  Low or High Temperature Bend Test for Fiber Optic Cable
7. TIA/EIA 455-41, FOTP-41  Compressive Loading Resistance of Fiber Optic Cables
10. TIA/EIA 455-81, FOTP-81  Compound Flow (Drip) Test for Filled Fiber Optic Cable
11. TIA 455-82, FOTP-82  Fluid Penetration Test for Fluid-Blocked Fiber Optic Cable
12. TIA/EIA 455-85, FOTP-85A  Fiber Optic Cable Twist Test
13. TIA/EIA 455-88, FOTP-88  Fiber Optic Cable Bend Test
14. TIA 455-91, FOTP-91  Fiber Optic Cable Twist-Bend Test
15. TIA 455-104, FOTP-104  Fiber Optic Cable Cyclic Flexing Test
17. TIA/EIA 455-181, FOTP-181  Lighting Damage Susceptibility Test for Optic Cables with Metallic Components
18. TIA/EIA-4720000-A  Generic Specification for Fiber Optic Cable
19. TIA-492AAAA-A  Detail Specification for 62.5-um Core Diameter/125-um Cladding Diameter Class Ia Graded-Index Multimode Optical Fibers
20. TIA 492-CAAB  Detail Specification for Class IVa Dispersion - Unshifted Single-Mode Optical Fibers with Low Water Peak
21. TIA 526-7 - OFSTP-7  Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant
1.03 DESIGN CONSIDERATIONS

A. Station Communications shall deploy a fiber optic cable distribution as follows:

1. Single-mode fiber optic cable shall be deployed where subsystem products are available. Single-mode fiber optic cable shall be deployed on the station facility and platform grounds inside CER cabinets and between CER and the DC. Single mode fiber optic cable shall also be deployed between stations CER’s and between station CER’s and wayside systems not located on station or platform grounds.

2. Fiber optic cable shall serve as the backbone medium between the station communications equipment room (CER) and communication distribution cabinet (DC). The fiber cable shall be placed in a physical ring backbone topology. Backbone fiber cables shall consist of 24-strand single-mode fiber cabling, which shall be of outside plant design for outdoor applications and plenum design for indoor applications. All fibers shall be terminated, tested and certified, whether working or spare (dark).

3. There will be no intermediate cross-connect, patching, consolidation point, or other termination of the fiber optic cable between the CER and the DC.

4. The fiber optic backbone will be configured in a physical ring topology. The CER and each field communications distribution cabinet will have physically redundant entrances to facilitate the ring topology.

5. To facilitate future integrated (fiber direct) subsystem devices, single-mode fiber optic backbone cable will be deployed. The minimum cable size will be 24-strand cable.

6. Upon receiving the fiber cable shipment reels at the site, the Contractor shall conduct all necessary testing to verify and demonstrate to the Engineer that the shipped fiber cables are acceptable. All deficient or rejected fiber cabling equipment shall be rejected and returned back to the vendor for substitution.

7. Use of Multi-mode fiber cable and the associated equipment solutions shall be avoided and could only be permitted as an exception (due to
lack of adequate substitute based on single-mode fiber solution) and only if approved by the Engineer.

1.04 SUBMITTALS

A. Refer to Section 17000, Basic Communications Technical Requirements, for related and additional submittal requirements.

B. Submittals shall consist of a complete design description, including detailed drawings, specifications, and submittals of all subsystems and elements within the subsystem. Each calculation, test procedure, final drawing and submittal shall be reviewed and signed by a BICSI Registered Communications Distribution Designer (RCDD). For submittals involving engineering design services required by governing codes and regulations; system design and design calculations shall be sealed and signed in blue ink by a professional engineer, currently registered in the State of California, for the discipline involved. The final design document shall contain sufficient details for construction.

C. Submittals shall include all materials, equipment, assembly and installation required to carry out the functions and purposes indicated in the Specifications, and to make the system suitable for the purpose for which it is intended, whether or not such materials, equipment, assembly and installation are specially indicated in the requirements of the Specifications.

D. Design submittal shall define interfaces between the systems. This includes both Communications and Signals.

E. Submit equipment lists including a table or list of model and part numbers for all proposed equipment and materials to be used for individual subsystems. Include the expected lead-time for each item while identifying in boldface type the ones with greater than 30 days. Group table or list for each subsystem with functional descriptions of equipment or material included.

1. Quantities by individual work location shall be included.

F. Submit Product Data Sheets with product information in sufficient detail to indicate that components meet these Specifications. The product model shall be indicated explicitly with arrow or underline on the product sheet submitted.

G. Submit calculations for each fiber optic cable span showing link margin and system gain.

H. Schedule: Submit schedule including identification and description of all major system cutover events or integration activities describing techniques, methods, duration and procedures.

I. Submit electrical, mechanical, and network communications block and functional diagrams with corresponding parts list using current AutoCAD standards.

J. Submit cable running lists per subsystem. Lists shall identify the size and type of cable, and identify the termination points of both cable ends. Include cable termination assignments by fiber strand or copper wire. Specify cable labeling (tags) for each cable per end.
K. Submit drawings showing equipment placement within the station. Include floor or wall profiles showing the location of equipment cabinets. Include vertical cabinet profiles showing the assigned placement of equipment within the cabinet. Depict all equipment within a cabinet, whether said equipment is new or existing.

L. Manufacturer Qualifications: Submit manufacturer’s qualifications. Include cable manufacturer’s ISO 9001 Certification Number.

1.05 QUALITY ASSURANCE

A. Materials, design, installation, and testing shall comply with all applicable Standards included herein. Be familiar with and adhere to the latest editions of these codes, regulations, specifications and standards.

B. Work shall meet or exceed the standards and procedures specified.

C. In the event of conflicts between reference standards, the most stringent provisions shall apply to the Work of this Section.

D. Manufacturer Pre-Qualification Requirements:

1. Obtain Engineer’s approval of cable manufacturers and installers. The Provide all data required for 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 shall demonstrate previous successful experience in supplying, testing and installation of fiber optic cable specified herein.

b. Quality Assurance Program

   i. The manufacturer of cables, in accordance with the requirements of these technical specifications, shall have in place or implement, an effective quality assurance program adhering to the requirements of ISO 9001 to ensure purchase control performance.

   ii. The cable manufacturer shall be ISO 9001 certified.

c. Warranty

   i. The manufacturer shall 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 fiber optic cable for transit applications; and that each such item and every part and component thereof shall comply with the Specifications.
ii. The Contractor shall monitor the manufacturers of the cable to assure that the Engineer approved Quality Assurance Program is being closely adhered to and that the fiber optic cable is being manufactured in accordance with these specifications.

iii. If the cable supplier is not the manufacturer of the fiber, the fiber manufacturer shall be identified.

1.06 DELIVERY, HANDLING, AND STORAGE

A. Packing: Ship cable on non-returnable wooden reels. The diameter of the drum shall be at least 20 times the diameter of the cable. Ship cable shall be shipped on reels substantial to withstand reasonable handling and shall be so designed that the inner end of the cable be accessible, but protected from injury. All ends of the cable shall be sealed to prevent entrance of moisture and securely fastened to prevent them from becoming loose during transit.

B. Marking: Label each reel on the outside flange with the following information:

1. Manufacturer’s name
2. Contract name and number
3. Cable identification number
4. Cable length
5. Date of manufacture
6. Copy of the factory test results

PART 2- PRODUCTS

2.01 FIBER OPTIC CABLE

A. General Fiber Optic Cable Specifications:

1. All fibers in the cable shall be usable and meet required specifications.
2. The life expectancy of the cable shall be 25 years for service in a railroad and transit environment.
3. The cable shall be designed for installation in underground conduit, wet or dry environments, including alternating wet and dry conditions.
4. All fiber optic cable run in conduits or duct banks shall be an accepted product of the USDA Rural Utilities Service (RUS) 7 CFR 1755.900 and meet the requirements of ICEA S-87-640.
5. Each optical fiber shall be sufficiently free of surface imperfections and inclusions to meet the optical, mechanical, and environmental requirements of this specification.
6. Each optical fiber shall consist of a germanium-doped silica core surrounded by a concentric glass cladding. The fiber shall be a matched clad design.

7. Each optical fiber shall be proof tested by the fiber manufacturer at a minimum of 100 kpsi (0.7 GN/m²).

8. The fiber shall be coated with a dual layer acrylate protective coating. The coating shall be in physical contact with the cladding surface.

9. The attenuation specification shall be a maximum value for each cabled fiber at 23 ± 5 °C on the original shipping reel.

B. Enhanced Single-mode Optical Fiber for Telecommunications Applications:


2. Geometry Standards:
   a. Cladding Diameter (μm) = 125.0 ± 0.7
   b. Core-to-Cladding Concentricity (μm) ≤ 0.5
   c. Cladding Non-Circularity ≤ 0.7 %
   d. Mode Field Diameter @ 1550 nm (μm) = 10.3 ± 0.5
   e. Effective Area, Aeff (Characterized): (μm²) = 72
   f. Coating Diameter (μm) = 245 ± 5
   g. Colored Fiber Nominal Diameter (μm) = 242 ± 7
   h. Fiber Curl radius of curvature (m) > 4.0 m

3. Optical Standards:
   a. Cabled Fiber Attenuation @ 1310 nm (dB/km) ≤ 0.35
   b. Cabled Fiber Attenuation @ 1550 nm (dB/km) ≤ 0.25
   c. Point discontinuity @ 1550 nm (dB) ≤ 0.25
   d. Cable Cutoff Wavelength (λccf) (nm) ≤ 1480
   e. Total Dispersion (ps/(nm•km))
      1300 nm = ≤ 3.0
      1530 - 1565 nm = ≤ 18.0
1565 - 1625 nm = ≤ 22.0

f. Cabled Polarization Mode Dispersion (ps/km) ≤ 0.1 max

g. Water Peak Attenuation @1383+/− 3 nm; ≤ 2.1 dB/km

4. Environmental and Mechanical Specifications:

a. Temperature Cycling -60°C to +85°C

b. Temperature-Humidity Cycling -10°C to +75°C, 98 % RH

c. Each optical fiber shall be proof tested by the fiber manufacturer at a minimum of 100 ksi (0.7 GN/m2).

d. The fiber shall be coated with a dual layer acrylic protective coating. The coating shall be in physical contact with the cladding surface.

e. Crush Resistance = 10 kN/m (685 Ib/ft) length of cable.

f. Cable Outside Diameter equal or < 0.65 inch

g. Weight per 1000 linear foot equal or <160lbs

h. Minimum Bending Radius:

   Installation, 15X Diameter
   Static, 12X Diameter

5. Cable Construction (Jacketed and Armored, Duct or Burial):

a. The cable meets the specifications set forth in Bellcore GR-20-CORE. Cable is listed by RUS to ICEA S-87-640 – ISO 9001 – 14001 – TL 9000 and shall be approved for use by RUS.

b. Optical fibers shall be placed inside a loose buffer tube. The nominal outer diameter of the buffer tube shall be either 2.5 mm or 3.0 mm. Each buffer tube shall contain up to 12 fibers. The fibers shall not adhere to the inside of the buffer tube. The buffer tubes shall be resistant to external forces and shall meet the buffer tube cold bend and shrink-back requirements of USDA RUS 7 CFR 1755.900.

c. Each fiber shall be distinguishable by means of color coding in accordance with TIA-598. The fibers shall be colored with ultraviolet (UV) curable inks. Buffer tubes containing fibers shall be color coded with distinct and recognizable colors in accordance with TIA-598. Buffer tube colored stripes shall be inlaid in the tube by means of co-extrusion when required. The nominal stripe width shall be 1.0 mm. In buffer tubes containing multiple fibers, the colors shall be stable across the specified storage and operating temperature range and not subject to
fading or smearing onto each other or into the gel filling material. Colors shall not cause fibers to stick together.

d. Fillers may be included in the cable core to lend symmetry to the cable cross-section where needed. Fillers shall be placed so that they do not interrupt the consecutive positioning of the buffer tubes. In dual layer cables, any filler shall be placed in the inner layer. Fillers shall be nominally 2.5 mm or 3.0 mm in outer diameter.

e. The central member shall consist of a dielectric, glass reinforced plastic (GRP) rod. The purpose of the central member is to provide tensile strength and prevent buckling. The central member shall be over coated with a thermoplastic when required to achieve dimensional sizing to accommodate buffer tubes/fillers.

f. Each buffer tube shall be filled with a non-hygroscopic, non-nutritive to fungus, electrically non-conductive, homogenous gel. The gel shall be free from dirt and foreign matter. The gel shall be readily removable with conventional nontoxic solvents.

g. Buffer tubes shall be stranded around the dielectric central member using the reverse oscillation, or "S-Z", stranding process. Water wellable yarn(s) shall be applied longitudinally along the central member during stranding.

h. Two polyester yarn binders shall be applied contra-helically with sufficient tension to secure each buffer tube layer to the dielectric central member without crushing the buffer tubes. The binders shall be non-hygroscopic, non-wicking, and dielectric with low shrinkage.

i. For single layer cables, a water swellable tape shall be applied longitudinally around the outside of the stranded tubes/fillers. The water swellable tape shall be non-nutritive to fungus, electrically non-conductive, and homogenous. It shall also be free from dirt and foreign matter. For dual layer cables, a second (outer) layer of buffer tubes shall be stranded over the original core to form a two layer core. A water swellable tape shall be applied longitudinally over both the inner and outer layer. The water swellable tape shall be non-nutritive to fungus, electrically non-conductive, and homogenous. It shall also be free from dirt and foreign matter.

j. Cables shall contain two ripcords under the steel armor for easy armor removal. Additionally, armored cables that have an inner sheath shall also contain one ripcord under the inner sheath.

k. Tensile strength shall be provided by the central member, and additional dielectric yams as required. The dielectric yams shall be helically stranded evenly around the cable core.
l. Cables shall have an inner sheath of Medium Density Polyethylene (MDPE). The minimum nominal jacket thickness of the inner sheath shall be 1.0 mm. The inner jacket shall be applied directly over the tensile strength members (as required) and water swellable tape. A water swellable tape shall be applied longitudinally around the outside of the inner jacket.

m. The armor shall be a corrugated steel tape, plastic-coated on both sides for corrosion resistance, and shall be applied around the outside of the water blocking tape with an overlapping seam with the corrugations in register. The outer jacket shall be applied over the corrugated steel tape armor. The outer jacket shall be a MDPE with a minimum nominal jacket thickness of 1.4 mm. The polyethylene shall contain carbon black to provide ultraviolet light protection and shall not promote the growth of fungus.

n. The MDPE jacket material shall be as defined by ASTM D1248, Type II, Class C, Category 4 and Grades J4, E7 and E8. The jacket or sheath shall be free of holes, splits, and blisters. The cable jacket shall contain no metal elements and shall be of a consistent thickness.

o. The outer surface of the jacket of each shipping length of cable shall be permanently identified by printing (in a contrasting color) descriptive information on the outer surface of the jacket at intervals of 1500 mm (5 feet) or less. The information shall include identification (Caltrain Communications System), count of fibers, fiber type, date of manufacturing (month and year), manufacturer’s part number, manufacturer’s name, sequential meter or foot markings, a telecommunication handset symbol as required by Section 350G of the National Electrical Safety Code (NESC), fiber count, and fiber type. The actual length of the cable shall be within -0/+1 percent of the length markings. The print color shall be white, with the exception that cable jackets containing one or more co-extruded white stripes, which shall be printed in light blue. The height of the marking shall be approximately 2.5mm.

p. If the initial marking fails to meet the specified requirements, i.e., improper text statement, color, legibility, or print interval, the cable may be remarked using a contrasting alternate color. The numbering sequence shall differ from the previous numbering sequence, and a tag shall be attached to both the outside end of the cable and to the reel to indicate the sequence of remarking. The preferred remarking color shall be yellow, with the secondary choice being blue.

C. Multi-mode Fiber for Local Area Network (LAN) Applications:

1. Multimode fibers shall meet EIA/TIA-492AAAA- "Detail Specification for 62.5-\textmu m Core Diameter/125-um Cladding Diameter Class 1a Graded-
Index Multimode Optical Fibers." These fibers shall have the same specified performance and geometry values as noted below:

2. All fibers in the cable shall be usable and meet required specifications.

3. Each optical fiber shall be sufficiently free of surface imperfections and inclusions to meet the optical, mechanical, and environmental requirements of this specification.

4. Each optical fiber shall consist of a germanium-doped silica core surrounded by a concentric glass cladding. The fiber shall be a matched clad design.

5. The attenuation specification shall be a maximum value for each cabled fiber at 23 ± 5 degrees C on the original shipping reel.

6. Geometry:
   a. Core Diameter 62.5 ± 3.0um
   b. Core Non-Circularity ≤ 5 percent
   c. Cladding Diameter 125.0 ± 2.0um
   d. Cladding Non-Circularity < 2.0 percent
   e. Core-to-Cladding Concentricity ≤ 3.0um
   f. Coating Diameter 245 ± 5um
   g. Colored Fiber Nominal Diameter 253 – 259um

7. Optical:
   a. Cabled Fiber Attenuation
      i. 850 nm < 1.0 dB/km
      ii. 1300 nm ≤ 3.5 dB/km
   b. Point discontinuity
      i. 850 nm < 0.2 dB
      ii. 1300 nm ≤ 0.2 dB
   c. Macrobend Attenuation
      i. Turns: 100; Mandrel OD - 75 ± 2 mm, < 0.5 dB at 850 nm
      ii. Turns: 100; Mandrel OD - 75 ± 2 mm, < 0.5 dB at 1300 nm
d. Cabled Effective Bandwidth Modal
   850 nm, > 385 MHz/km

8. IEEE 802.3 GbE Distance
   a. 1000BASE-SX Window (850 nm), up to 500m
   b. 1000BASE-LX Window (1300 nm), up to 1000m

9. OFL Bandwidth
   a. 850 nm, > 200 MHz/km
   b. 1300 nm, > 500 MHz/km

10. Numerical Aperture 0.275 ± 0.015

11. Mechanical Specifications:
   a. Each optical fiber shall be proof tested by the fiber manufacturer
      at a minimum of 100 kpsi (0.7 GN/m²).
   b. The fiber shall be coated with a dual layer acrylate protective
      coating. The coating shall be in physical contact with the
      cladding surface.
   c. Crush Resistance = 10 kN/m (685 lb/ft) length of cable.
   d. Cable Outside Diameter < 0.65 inch
   e. Weight per 1000 linear foot < 160lbs
   f. Minimum Bending Radius
      i. Installation, 15X Diameter
      ii. Static, 12X Diameter
   g. Temperature (Operational)
      i. -30 degrees C (-22 degrees F) to +60 degrees C (140
         degrees
      ii. Continuous operation at -30 degrees C (-22 degrees F)
         without cracking or becoming brittle
   h. Temperature (Storage)
      i. -40 degrees F to +158 degrees F on reel
      i. Humidity @ 0 to 100 percent, inclusive
j. Tensile Strength
   i. Installation @ 2,700 N (600 lbf)
   ii. Static @ 890 N (200 lbf)

D. Single-mode station distribution fiber optic cable will be Superior Essex #110243T01 or Engineer approved equal.

E. Multi-mode station distribution fiber optic cable will be Superior Essex #130246G01 or Engineer approved equal.

2.02 FIBER CONNECTORS AND PASSIVE COMPONENTS

A. Fiber Connectors:
   1. FDP connectors shall be SC and LC connector type (as required). SC-type connectors shall be the preferred connector for all terminations and equipment interfaces. LC connectors are typically used by the fiber optic connections to the modern Ethernet switches.
   2. When available network products use connectors other than SC-type, optical patch cables shall be provided with the corresponding non-SC-type connector on the equipment end, and the SC-type connector on the distribution panel end. Example: SC-to-ST patch cord.
   3. Optical parameters of the connectors shall meet the requirements of EIA/TIA-568.
   4. SC-type fiber single-mode connectors shall be Hubbell FCSCSQ or approved Equal. SC-type and LC-type fiber connectors and ports for single-mode will be colored yellow. If multi-mode equipment is used, SC-type and LC-type fiber connectors and ports for multi-mode shall be colored orange. Where used, LC-type Single mode connectors shall be Hubbell #FCLCSM or Engineer approved equal.
   5. Where used, SC-type fiber Multi-mode connectors shall be Hubbell #FCSCMQ or approved Equal. Where used, LC-type fiber Multi-mode connectors shall be Hubbell #FCLCMM or Engineer approved equal.

B. Fiber Slack Enclosures:
   1. Enclosures shall be NEMA-12 type with hinged cover and securing mechanism.
   2. Enclosures shall be sized for 100 feet of cable slack.
   3. Hardware
      a. Hooks shall be provided to hold cable slack, with coils of required bend radius.
      b. Velcro ties to restrain cable shall be utilized.
C. Fiber Distribution Enclosure:

1. Enclosure
   a. The enclosure shall house the splice shelf and connector sleeve panels for all optical connections but as a minimum shall provide 48 connections for Single Mode and 48 connections for Multi-mode fibers.
   b. All OSP cable jackets and central strength members shall be secured to relieve strain.
   c. The enclosure shall be mountable in a standard 19” rack and be no more than 3 rack units high.

2. Fiber enclosure will be Hubbell #FCR350SE or Engineer approved equal.

D. Fiber Distribution Panels:

1. Distribution panels shall be a complete system of components by a single manufacturer.

2. Rack mountable connector housings shall be available for cross-connecting or inter-connecting purposes. The units shall provide for direct connecting and pigtail splicing.

3. Housings shall be mountable in an EIA-310 compatible 18.3 inch rack (19 inch EIA). The unit shall meet the design requirements of TIA-568.

4. Molded plastic parts shall meet flammability requirements of UL 94 V-0.

5. The connector housings shall have a labeling scheme that complies with TIA/EIA-606. The housing shall incorporate labeling via an adhesive backed label and a retractable sliding label panel that pulls out from the bottom front of the housing.

6. Housings shall be manufactured using 16-gauge aluminum and shall be finished with a Two-Tone Gunmetal Grey and/or anodized silver for durability. Installation fasteners shall be included and shall be black in color.

7. The unit shall be capable of connectorization and jumper management. The unit shall be capable of splicing or combination connectorization/splicing with the use of an additional splice tray kit.

8. Fiber Cable Routing: The Unit shall have a fiber routing guide platform located in the rear of the housing. The fiber routing guide platform shall be removable using two plunger style latches so that room can be made for an optional splice tray kit.

9. Jumper Routing:
a. The unit shall have a hinged top jumper management panel capable of locking in the horizontal or vertical position. When the top panel is locked in the horizontal position, it shall act as a jumper routing area in the top front of the housing and shall enclose the top of the housing.

b. When the hinged panel of the unit is locked in the vertical position it shall serve as a horizontal jumper management panel capable of routing jumpers out of the top of the housing. Total height of the housing shall be 5U or less.

10. Fan-Out Devices:

a. Provisions for mounting up to 12 fiber fan-out devices shall be incorporated into the housing via a removable slack storage platform in the rear of the housing.

b. Splice capacity shall be 12 splice trays.

11. Units shall include a clamshell-type cable clamping mechanism to provide cable strain relief. The cable clamp shall accept one cable from 0.37 inches-1.12 inches in diameter. The cable clamp mechanism shall also handle multiple smaller fiber count cables when used with a multiple cable insert. The total cable capacity per clamp shall be five cables (0.4 inches) OD when used with the multiple cable insert. Housing cable clamp capacity shall be two clamps. Additional cable clamps shall be available as an accessory kit.

12. The housing shall have four grommet openings for cable entry in the rear of the housing. The unit shall have two removable panels on both the left and right rear of the housing if more than four cable entries are required.

13. Front and rear doors of the connector housings shall be hinged and removable for ease of cable installation.

14. Access Doors:

a. The front doors shall be made from tinted polycarbonate.

b. Front and rear doors shall utilize a single slide latch to provide ready access and closing. An opening shall be provided in the front and rear doors so that an optional key lock kit may be used. The opening shall be filled with a removable plastic insert so that dust may not enter if the optional lock kit is not used. There shall be a removable retaining bracket to prevent the door from being unintentionally slid off the hinges.

15. The housing shall accommodate the future installation of LC, SC, ST, FC, D4, or MTRJ, type connector modules. Each module shall provide twelve connector sleeves.
16. The FDP will be Hubbell #FCR525SPR or Engineer approved equal. FDP adapter panel with 6 SC-type (or LC-type, if required) fiber bulkhead connectors will be Hubbell #FSPSC6 (or FSPLC6, if required) or Engineer approved equal. Adapter panels used for single-mode fiber will have yellow SC-type (or LC-type, if required) bulkhead ports. Adapter panels used for multi-mode fiber will have orange SC-type (or LC-type, if required) bulkhead ports.

E. Splice Shelf:
   1. The splice shelf shall accept slide in/out splice trays for a maximum number of connectors and for the fiber types to be installed.
   2. Each splice tray shall restrain and protect fusion or mechanical splices.
   3. The splice tray shall hold 12 fusion splices and will be Hubbell #STRAY12F or Engineer approved equal.

F. Connector Sleeve:
   1. Connector sleeves shall be the SC-type (or LC type, if required). The connector sleeve shall meet TIA-568-B.3 requirements when connecting mated pairs.
   2. The FDP shall be fully populated with connector sleeves.
   3. Dust Caps shall be provided for all sleeves.
   4. Loss across connection shall not exceed the following, with optical attenuators removed:
      a. Single Mode: 0.5 db
      b. Multi-Mode: 0.5 db
   5. The FDP sleeves shall be capable of accepting optical attenuators as required for maintaining the Optical Loss budget.

G. Slack Retention:
   1. Slack in pigtails and patch cords shall be neatly coiled and retained such that the minimum-bending radius shall not be exceeded.
   2. Slack shall be sufficient for accessing splice shelves and connectors.

2.03 OPTICAL FIBER PATCH CORDS AND PIGTAILS

A. Patch cords and pigtails shall be cable assemblies consisting of flexible optical fiber cable with SC (or LC, if required) compatible connectors. Patch cords shall be complete factory fabricated assemblies from manufacturer's standard product lines. Fiber optic jumper cables shall meet the following requirements.
B. Patch Cord Assemblies:

1. The cable construction shall allow a small bend radius for installation in space-constrained areas. The cable shall contain a dielectric strength member and a protective outer jacket.

2. The Patch Cord shall comply with the requirements of TIA-568-B.3.

C. Connectors:

1. One SC-type (or LC-type, if required) duplex connector shall be provided on Patch cords.

2. One SC-type (or LC-type, if required) simplex connector shall be provided on pigtails, with the other end prepared for splicing.

3. SC-type (or LC-type, if required) connectors used for single-mode fiber will be colored yellow. SC-type (or LC-type, if required) connectors used for multi-mode fiber will be colored orange.

D. Fiber Cable:

1. Patch cords and pigtails shall utilize a two-fiber zip-cord type jacketed cable, in lengths required to meet minimum bend radius while connected and routed through cable management hardware but no less than 6 feet in length. The cable jacket color shall be orange for multi-mode and yellow for single mode cable. The fiber core size shall also be identified on the outer jacket.

2. The optical fiber shall meet the same characteristic requirements of the distribution panel terminated cable to which it mates.

3. Tensile strength of the jacketed cable shall be greater than or equal to 20 lbs.

E. Single-mode pigtails with SC-type (or LC-type, if required) connector on one end and the other end bare fiber, 3 meters length, shall be Hubbell #FPSCS3SM (or Hubbell #FPLCC3SM, if required) or approved equal. Where used, multi-mode pigtails with SC-type (or LC-type, if required) connector shall be Hubbell #FPSCS3MM (or Hubbell #FPLCS3MM, if required) or Engineer approved equal.

2.04 INNERDUCT

A. Constructed of flame retardant PVC or FCP material and shall meet the following flammability requirements:

1. OSP, inside building horizontal (no more than 50 feet from the point of entrance), and inside building riser inner-duct shall meet the UL 2024 (raceways) flame test.

2. Inner-duct installed in any air plenum environment shall meet NFPA 262-2002.
B. Inner-duct shall have smooth exterior and interior wall, and semi-rigid construction.

C. Inside building horizontal and riser inner ducts shall be flexible and corrugated type.

D. Compatible with the fiber optic cable installed within.

E. Inner diameter shall be 1 inch minimum.

F. Couplers, if used, shall not reduce the inside diameter of the inner-duct.

G. All unused inner-duct shall be preinstalled with lubricated pull tape or line.

H. Inner-duct used to house single-mode fiber cable will be colored yellow. Inner-duct used to house multi-mode fiber cable will be colored orange.

2.05 WIRE PULLING LUBRICANT

A. Wire Pulling Lubricant shall have the following characteristics:

1. Polymer-based

2. Average Coefficient of Friction: \( \leq 0.055 \)

3. Temperature Range: -28 degrees F -180 degrees F

4. Compatible with all cable types

2.06 AIR BLOWN FIBER OPTIC SYSTEMS

A. General Fiber Specifications:

1. All fibers in the bundle must be usable and meet required specifications.

2. Each optical fiber shall be sufficiently free of surface imperfections and inclusions to meet the optical, mechanical, and environmental requirements of this specification.

3. Each optical fiber shall consist of high-grade silica, doped as necessary to achieve the required light guiding properties. The fiber shall be a matched clad, step-index design.

4. The fiber shall be coated with a dual layer of ultra-violet cured acrylate resin protective coating. The coating shall be in physical contact with the cladding surface.

5. The attenuation specification shall be a maximum value for each bundled fiber at 23 ± 5 °C on the original shipping reel.

6. The fibers will be contained in a soft inner acrylate layer, an outer harder layer which protects the fibers from damage, and a low friction layer that assists in improved blowing distance, typically in excess of 1000 meters.
7. Fiber bundle units will be available in a range of lengths up to 6000 meters.

B. The main optical, geometrical, and physical characteristics will be compliant with ITU-T Rec. G.652 C/D for Low Water-peak Single-mode Fiber.

1. Geometry Standards:
   a. Cladding Diameter (μm) = 125.0 ± 0.7
   b. Core Concentricity (μm) ≤ 0.84
   c. Cladding Non-Circularity ≤ 1.0 %
   d. Mode Field Diameter @ 1310 nm (μm) = 8.8 – 9.6
   e. Effective Area, Aeff (Characterized): (μm²) = 72
   f. Coating Concentricity (μm) ≤ 12.0

2. Optical Standards:
   a. Cabled Fiber Attenuation @ 1310 nm (dB/km) ≤ 0.38
   b. Cabled Fiber Attenuation @ 1550 nm (dB/km) ≤ 0.26
   c. Point discontinuity @ 1550 nm (dB) ≤ 0.1
   d. Attenuation at 1383 nm (dB/km) ≤ 0.35
   e. Attenuation Uniformity over 2km (dB/km) ≤ 0.05
   f. Dispersion Slope @ ps/(nm².km) ≤ 0.089
   g. Cable Cutoff Wavelength (λccf) (nm) ≤ 1480
   h. Total Dispersion (ps/(nm•km))
      1285 - 1330 nm ≤ 3.5
      1550 nm ≤ 18.0
   i. Cabled Polarization Mode Dispersion (ps/km) ≤ 0.5
   j. Water Peak Attenuation @ 1383+/− 3 nm; ≤ 2.1 dB/km

C. Environmental and Mechanical Tests and Specifications:

1. Operation / Storage -10°C to +60°C yields ≤ 0.07 db/km @ 1310 and 1550 nm.

2. Condensation tested -10°C to +65°C @ 93% RH for 24 hours x 10 yields ≤ 0.07 db/km @ 1310 and 1550 nm.
3. Water immersion test at +20°C for 2000 hours yields ≤ 0.07 db/km @ 1310 and 1550 nm.

4. Cold tested at -20°C for 96 hours yields ≤ 0.07 db/km @ 1310 and 1550 nm.

5. Each optical fiber shall be proof tested by the fiber manufacturer at a minimum of 100 kpsi (0.7 GN/m²).

6. Bend tested @ 40 mm (2 & 4 fibers) or 60 mm (8 fibers) yields no change in attenuation after test.

7. Aged Bend tested (60°C for 1000 hours) 40 mm (2 & 4 fibers) or 60 mm (8 fibers) yields no change in attenuation after test.

8. Tensile Strength tested @ 1W N (9.81x mass of 1km) ≤ 0.4% (max fiber strain)

9. 12 Fiber Outside Diameter ≤ 1.3 mm

10. 12 Fiber Weight ≤ 1.5 g/m

11. 12 Fiber Blowing Distance 1000m typical

12. 12 Fiber Breakout 8 minutes typical

2.07 TECHNICAL SPECIFICATIONS FOR AIR BLOWN FIBER DUCT

A. Air blown fiber tube installed in existing duct, conduit, or inside buildings will meet the following criteria:

1. Tubes will be low friction HDPE in small diameters for air blown fiber tubes up to 12 fibers per tube.

2. Each 12-fiber primary tube will have an outside diameter (O/D) of 5 mm.

B. A secondary HDPE fiber duct will house multiple primary 5 mm fiber tubes with the following specifications:

<table>
<thead>
<tr>
<th>Fiber Capacity</th>
<th>O.D (mm)</th>
<th>Nominal Weight (g/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 x 5mm tubes (24 fibers)</td>
<td>12.8-13.8</td>
<td>78</td>
</tr>
<tr>
<td>4 x 5mm tubes (48 fibers)</td>
<td>14.8-16.5</td>
<td>116</td>
</tr>
<tr>
<td>7 x 5mm tubes (84 fibers)</td>
<td>17.8-19.4</td>
<td>159</td>
</tr>
<tr>
<td>12x5mm tubes (144 fibers)</td>
<td>23.0-24.8</td>
<td>234</td>
</tr>
<tr>
<td>24x5mm tubes (288 fibers)</td>
<td>32.3-34.4</td>
<td>422</td>
</tr>
</tbody>
</table>

C. The secondary multi-tube duct will include a moisture barrier aluminum shield and outer polyethylene sheath. A ripcord will be included for easy cable access. The following shall apply to all secondary multi-tube assemblies:
1. Maximum tensile strength (N) = 1W; tested in accordance with IEC 60794-1-2 Method E1. There will be no permanent deformation of the primary or secondary assemblies after an applied load of 1.0 (spec.weight kg/km) N at 20 mm/minute.

2. The Crush Rating (KN) = 1; tested in accordance with IEC 60794-1-2 Method E3. There will be no permanent deformation of the primary assemblies greater than 0.5 mm after a maintained load of 1KN for 1 minute.

3. The minimum bend radius (mm) = 12 x diameter

4. Stress crack resistance will be tested in accordance with BS6469 Section 99.1 with chemical Caflon CF30.

5. Individual fiber tubes will be opaque or translucent for fiber visibility.

6. Secondary multi-tube duct will be available on drums up to 3000m in length.

D. Air blown fiber tube installed outside, direct bury, will meet the following criteria:

1. Tubes will be low friction HDPE in small diameters for air blown primary fiber tubes up to 12 fibers per tube.

2. Each 12-fiber primary tube will have an outside diameter (O/D) of 5 mm.

E. A secondary HDPE fiber duct will house multiple primary 5 mm fiber tubes with the following specifications:

<table>
<thead>
<tr>
<th>Fiber Capacity</th>
<th>O.D (mm)</th>
<th>Nominal Weight (g/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 x 5mm tubes (24 fibers)</td>
<td>11.0-13.2</td>
<td>142</td>
</tr>
<tr>
<td>4 x 5mm tubes (48 fibers)</td>
<td>18.1-22.3</td>
<td>204</td>
</tr>
<tr>
<td>7 x 5mm tubes (84 fibers)</td>
<td>21.6-23.3</td>
<td>278</td>
</tr>
<tr>
<td>12x5mm tubes (144 fibers)</td>
<td>28.2-29.5</td>
<td>479</td>
</tr>
<tr>
<td>24x5mm tubes (288 fibers)</td>
<td>37.8-39.1</td>
<td>755</td>
</tr>
</tbody>
</table>

F. The secondary multi-tube duct will include a moisture barrier aluminum shield and two (2) heavy duty outer polyethylene sheath layers. A ripcord will be included for easy cable access. The following shall apply to all secondary multi-tube assemblies:

1. Maximum tensile strength (N) = 1W; tested in accordance with IEC 60794-1-2 Method E1. There will be no permanent deformation of the primary or secondary assemblies after an applied load of 1.0 (spec.weight kg/km) N at 20 mm/minute.

2. The Crush Rating (KN) = 2; tested in accordance with IEC 60794-1-2 Method E3. There will be no permanent deformation of the primary
assemblies greater than 0.5 mm after a maintained load of 2 KN for 1 minute.

3. The minimum bend radius (mm) = 12 x diameter.

4. Stress crack resistance will be tested in accordance with BS6469 Section 99.1 with chemical Caflon CF30.

5. Individual fiber tubes will be opaque or translucent for fiber visibility.

6. Secondary multi-tube duct will be available on drums up to 3000 m in length.

G. Air blown fiber tube installed outside, direct bury, armored, will meet the following criteria:

1. Tubes will be low friction HDPE in small diameters for air blown primary fiber tubes up to 12 fibers per tube.

2. Each 12-fiber primary tube will have an outside diameter (O/D) of 5 mm.

3. A secondary HDPE fiber duct will house multiple primary 5 mm fiber tubes with the following specifications:

<table>
<thead>
<tr>
<th>Fiber Capacity</th>
<th>O.D (mm)</th>
<th>Nominal Wt (g/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 x 5mm tubes (24 fibers)</td>
<td>11.9</td>
<td>353</td>
</tr>
<tr>
<td>4 x 5mm tubes (48 fibers)</td>
<td>18.9</td>
<td>536</td>
</tr>
<tr>
<td>7 x 5mm tubes (84 fibers)</td>
<td>21.9</td>
<td>630</td>
</tr>
<tr>
<td>12x5mm tubes (144 fibers)</td>
<td>27.1</td>
<td>756</td>
</tr>
<tr>
<td>24x5mm tubes (288 fibers)</td>
<td>36.5</td>
<td>1071</td>
</tr>
</tbody>
</table>

H. The secondary multi-tube duct will include an inner polyethylene sheath layer, a corrugated armored layer, and an outer heavy duty polyethylene sheath layer. A ripcord will be included for easy cable access. The following shall apply to all secondary multi-tube assemblies:

1. Maximum tensile strength (N) = 1W; tested in accordance with IEC 60794-1-2 Method E1. There will be no permanent deformation of the primary or secondary assemblies after an applied load of 1.0 (spec.weight kg/km) N at 20 mm/minute.

2. The Crush Rating (KN) = 2; tested in accordance with IEC 60794-1-2 Method E3. There will be no permanent deformation of the primary assemblies greater than 0.5 mm after a maintained load of 3KN for 1 minute.

3. The minimum bend radius (mm) = 12 x diameter.
4. Stress crack resistance will be tested in accordance with BS6469 Section 99.1 with chemical Caflon CF30.

5. Individual fiber tubes will be opaque or translucent for fiber visibility.

6. Secondary multi-tube duct will be available on drums up to 3000m in length.

2.08 SOURCE QUALITY CONTROL - CABLE FACTORY TESTING

A. Factory tests shall be performed in accordance with TIA/EIA -455.

B. Cable shall be tested on-reel prior to shipment.

C. End to end loss shall be recorded for each fiber at 1,310 nm, 1,550 nm and 1,625 nm (for Single-mode).

D. End to end loss shall be recorded for each multi-mode fiber at 850nm, and 1,300 nm.

E. OTDR with hardcopy record shall be provided for each single mode fiber, at 1,300 nm, 1,550 and 1,625 nm.

F. OTDR with hardcopy record shall be provided for each multi-mode fiber, at 850 nm and 1,300 nm.

G. Polarized Modal Dispersion (PMD) for each single mode fiber shall be measured using a PMD analyzer and polarized light source.

H. Chromatic optical dispersion shall be tested for each single mode fiber.

I. Certified copies of tests results shall be submitted to the Engineer as described in these specifications 14 days after completion of each test.

PART 3- EXECUTION

3.01 INSTALLATION

A. All optical cable installation shall be accomplished in accordance with the approved plan.

B. All horizontal and backbone LAN fiber optic cable shall be installed in inner-duct. OSP fiber optic cable shall be installed in inner-duct at locations outside of the wayside trough as indicated in the Contract Drawings, through manholes, and through duct bank conduits. All duct bank four inch communications conduits serving fiber optic cable shall contain four 1 inch inner-ducts each. No more than one OSP fiber optic cable shall be installed in a single inner-duct. The inner-duct shall be installed without coils or twists.

C. Pull locations shall be selected to protect the cable on the reel and in slack loops. Be responsible for protecting cable after working hours where cable installation is not completed during a single shift. Cables damaged due to Contractor’s negligence while installing cable shall be replaced.
D. Pull lengths shall be designed to allow a 20 percent margin in cable tensile strength. Do not exceed the lesser of 80 percent of the cable's maximum tensile rating or 600 lbs during installation. No residual tension shall remain on the cable after installation except that due to the cable's weight in the vertical rise. Wire Pulling Lubricant shall be used to reduce tension on the cable during the installation process.

E. If a winch or pulling machine is used during installation, a dynamometer shall be used to monitor the tension on the cable. The dynamometer shall be certified as calibrated and shall hold the peak value of the cable pull. The peak value shall be recorded and forwarded to the Engineer as part of the installation test data submittals.

F. The maximum vertical rise shall be defined as the distance over which the cable is self-supporting. Cable strain relief shall be used at the top of each vertical rise and no less than every time that 80 percent of vertical rise rating of the cable is exceeded.

G. Do not exceed the cable's minimum bend radius for cable under tension or long term installation/storage.

H. Continuity of cable shall be maintained between termination or splice locations shown on the Contract Drawings. Additional splices shall not be allowed without the prior written Engineer approval.

I. Notify the Engineer in writing at least 48 hours in advance of installation of each section of optical cable.

J. All cable entrance openings in equipment enclosures, houses, rooms and junction boxes shall be sealed with either a compression type fitting or pliable sealing compound after the cable is in place. Sealing compounds for rooms, houses, walls, or other partitions shall be fire retardant per ASTM E-814. Sealing compound shall be used to seal the area around cable where the cable emerges from the end of a conduit, pipe, or duct bank. All spare conduits shall be sealed or plugged in an Engineer approved manner.

3.02 TERMINATION

A. Slack in Fiber Slack Enclosures (FSE's) shall be carefully coiled in order to avoid violating the short and long term minimum bend radius. Supply a minimum of 150 feet of slack at each termination of the cable inside the FSE.

B. Slack in Fiber Distribution Panels (FDP's) shall be restrained and shall be sufficient for strain relief.

C. The central strength member of cable shall be attached to the FDP. The outer jacket of cable shall be attached to the FDP with a cable clamp.

D. All fiber optic splices shall be fusion splices. Perform splicing at fiber slack enclosures only for the purposes of passing an optical connection through a Communications House. Fusion splicing shall be performed by qualified personnel utilizing a splicer equipped with Local Injection and Detection (LID) to
optimize splices. The loss across each spliced fiber shall be less than or equal to 0.04 db.

E. All fiber optical terminations at communications houses and wayside facilities shall be field or factory terminated.

F. Notify the Engineer in writing at least one week in advance of terminating each section of optical cable.

G. Where armored cable is utilized, the armor shall be grounded to the communications room ground bus at one termination location.

3.03 FIELD QUALITY CONTROL

A. Cable Factory Tests: See Source Quality Control herein.

B. Cable Plant Field Tests:
   1. Tests shall be performed after installation is complete.
   2. One week advance notice to the Engineer shall be provided.
   3. Optical attenuation from FDP to FDP shall be recorded.
   4. Every fiber optic cabling link shall be tested in accordance with the field test specifications defined by the TIA-568-B.3 (or by the required network application standards) whichever is more demanding.
   5. TIA-568-B.3, shall be used to define the passive cabling network, to include cable, connectors, and splices (if present), between two optical fiber patch panels (connecting hardware). This TIA document shall be used to describe all applicable link segments. Tests shall include the representative connector performance at the connecting hardware associated with the mating of patch cords but not the performance of the connector at the interface with the test equipment.
   6. All of the cabling links installed shall be tested and shall pass the requirements of the standards mentioned in above. Any failing link shall be diagnosed and corrected prior to the system acceptance. The corrective action shall be followed with a new test to prove that the corrected link meets the performance requirements. The final and passing result of the tests for all links shall be provided in the test results documentation in accordance with Section 3.04 below.
   7. Trained technicians who have successfully attended a required training program and have obtained a certificate, as proof thereof shall be used to execute the tests. These certificates may have been issued by any of the following organizations or an equivalent organization:
      a. The manufacturer of the fiber optic cable and/or the fiber optic connectors
b. The manufacturer of the test equipment used for the field certification

c. Training organizations authorized by BiCSI (Building Industry Consulting Services International), or by the ACP (Association of Cabling Professionals™).

8. Field test instruments for multimode fiber cabling shall meet the requirements of TIA-526-14. The light source shall meet the launch requirements of TIA-455-78. This launch condition can be achieved either within the field test equipment or by use of an external mandrel wrap (as described in clause 11 of TIA-568) with a Category 1 light source. Field test instruments for single mode fiber cabling shall meet the requirements of TIA-526-7.

9. The test instrument calibration date shall be within the calibration period recommended by the vendor in order to achieve the vendor specified measurement accuracy.

10. The fiber optic launch cables and adapters shall be of high quality and the cables shall not show excessive wear resulting from repetitive coiling and storing of the test instrument interface adapters.

11. The Pass or Fail condition for the link-under test is determined by the results of the required individual tests.

12. A Pass or Fail result for each parameter is determined by comparing the measured values with the specified test limits for that parameter.

13. An Engineer representative shall be invited to perform field-testing. The representative shall be notified of the start date of the testing phase five business days before testing.

14. The Engineer’s representative shall select up to five percent of the links installed. The representative (or his authorized delegate) shall test these selected links and the results are to be stored in accordance with the prescriptions in this Section. The results obtained shall be compared to the data provided by the Contractor. If the sample results differ in terms of the pass/fail determination, repeat testing of the affected link under observation of the Engineer.

C. Cable Plant Performance Test Parameters:

1. In compliance to TIA 568, the single performance parameter for field-testing of fiber optic links shall be link attenuation (insertion loss).

2. The link attenuation shall be calculated by the following formulas specified in ANSI/TIA/EIA 568:

   a. Link Attenuation = Cable Attenuation + Connector Attenuation + Splice Attenuation

   b. Cable Attenuation (db) = Attenuation Coefficient (db/km) x Length (km)
c. Connector Attenuation (db) = number of connector pairs x connector loss (db). Maximum allowable connector loss = 0.75 db

d. Splice Attenuation (dB) = number of splices (S) x Splice loss (db). Maximum allowable splice loss = 0.3 db

e. The values for the Attenuation Coefficient are listed below:
   i. Single mode (outside plant), 1310nm: 0.5 db/km
   ii. Single mode (outside plant), 1550nm: 0.5 db/km
   iii. Multimode, 850 nm: 3.5 db/km
   iv. Multimode, 1300 nm: 1.5 db/km

f. Link attenuation shall not include any active devices or passive devices other than cable, connectors, and splices, i.e., link attenuation shall not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers.

g. Test equipment that measures the link length and automatically calculates the link loss based on the above formulas is preferred.

3. The above link test limits attenuation is based on the use of the One Reference Jumper Method specified by TIA-526-7, Method A.1; or the equivalent method. The user shall follow the procedures established by these standards or application notes to accurately conduct performance testing.

4. Multimode distribution links shall be tested at 850 nm and 1300 nm in accordance with ANSI/EIA/TIA-526-14. Because backbone length and the potential number of splices vary depending upon site conditions, the link attenuation equation shall be used to determine limit (acceptance) values.

5. Single-mode backbone links shall be tested at 1310 nm and 1550 nm in accordance with TIA-526-7, Method A.1, One Reference Jumper or the equivalent method. All single-mode links shall be certified with test tools using laser light sources at 1310 nm and 1550 nm.

6. Links to be used with network applications that use laser light sources (under-filled launch conditions) shall be tested with test equipment based on laser light sources. This rule shall be followed for cabling systems to support Gigabit Ethernet. Gigabit Ethernet only specifies laser light sources. For Gigabit Ethernet compliant certification (IEEE Std 802.3Z application), use test equipment that uses a VCSEL (Vertical cavity surface emitting laser) at 850 nm (compliant with 1000BASESX) and a FP laser at 1310 nm (compliant with 1000BASELX).
7. Each fiber optical link terminated with an optical adapter system that does not impose a transmission direction because the adapters are not or cannot be ganged shall be tested and documented in both directions since the direction of the signal transmission cannot be predicted at the time of installation.

D. OTDR Testing:

1. All cables shall be OTDR tested at 1310 nm and 1550 nm (for Single-mode) operating wavelengths for anomalies and to ensure uniformity of cable attenuation and connector insertion loss.

2. OTDR tests shall be performed utilizing a pulse suppressor such that the FDP termination shall be shown.

3. All OTDR testing procedures and field test instruments shall comply with applicable requirements of:
   a. TIA 455-78
   b. TIA 455-133

4. Each fiber link and channel shall be tested in one direction.

5. A launch cable shall be installed between the OTDR and the first link connection.

6. A receive cable shall be installed after the last link connection.

7. Optical Return Loss (ORL) for each link shall be measured.

8. Fiber Length shall be measured

9. Test Results:
   a. Reflective events shall not exceed -40 dB
   b. Connections shall not exceed 0.75 dB of attenuation
   c. Non-reflective events (splices) shall not exceed 0.3 db
   d. Point discontinuities shall not exceed 0.1 db
   e. ORL shall be less than -30 dB

10. OTDR Test results shall include OTDR link and channel traces and event tables at the required wavelength(s) and the length for each optical fiber as calculated by the OTDR.

11. An Optical Spectrum scan of each link shall be performed using an optical spectrum analyzer and optical switch to examine fiber nonlinear effects including but limited to Brillouin scattering and four wave mixing across the fiber’s usable light spectrum.
12. Polarized Modal Dispersion (PMD) for each link shall be measured using a PMD analyzer and polarized light source. Total PMD for each link shall be less than 10 ps.

E. Cable Plant Test Result Documentation:

1. The test result information for each link shall be recorded in the memory of the field tester upon completion of the test.

2. The test result records saved by the test instrument shall be transferred into a Windows™-based database utility that allows for the maintenance, inspection and archiving of these test records. A guarantee shall be made that these results are transferred to the PC unaltered, i.e., “as saved in the tester” at the end of each test. The popular 'csv' format (comma separated, value format) does not provide adequate protection and shall not be acceptable.

3. The database records of all fiber shall be stored and delivered on CD-ROM; this CD-ROM shall include the software tools required to view, inspect, and print any selection of test reports.

4. A paper copy of the test results shall be provided that lists all the links that have been tested with the following summary information.
   a. The identification of the link in accordance with the naming convention defined in the overall system documentation.
   b. The overall Pass/Fail evaluation of the link-under-test including the Attenuation worst-case margin (margin is defined as the difference between the measured value and the test limit value).
   c. The date and time the test results were saved in the memory of the tester.

5. General Information to be provided in the electronic data base containing the test result information for each link:
   a. The identification of site
   b. The overall Pass/Fail evaluation of the link-under-test
   c. The name of the standard selected to execute the stored test results
   d. The cable type and the value of the 'index of refraction' used for length calculations
   e. The date and time the test results were saved in the memory of the tester
   f. The brand name, model and serial number and calibration data of the tester
g. The revision of the tester software and the revision of the test standards database in the tester

6. The detailed test results data to be provided in the electronic database for each tested optical fiber shall contain the following information.

a. The identification of the link/fiber in accordance with the naming convention defined in the overall system documentation.

b. The insertion loss (attenuation) measured at each wavelength, the test limit calculated for the corresponding wavelength and the margin (difference between the measured attenuation and the test limit value).

c. The link length shall be reported for each optical fiber for which the test limit was calculated based on the formulas specified herein under Cable Plant Performance Test Paragraphs.

END OF SECTION
SECTION 17460
POWER SUPPLIES AND DISTRIBUTION

PART 1 - GENERAL

1.01 DESCRIPTION
A. Section includes requirements for Power Supplies and Power Distribution for Station communications.

1.02 REFERENCE STANDARDS
A. American National Standards Institute (ANSI):
   2. C62.41 Recommended Practice on Surge Voltage in Low Voltage Power Circuits

B. California Electric Code (CEC)

C. Federal Communication Commission (FCC):
   1. FCC Rules and Regulations 47, Part 15, Subpart J Class A

D. Institute of Electrical and Electronics Engineers (IEEE):
   1. 446 Recommended Practices for Emergency Standby Power System for Industrial and Commercial Applications
   2. 519 Recommended Practices and Requirements For Harmonic Control in Electrical Power Systems
   3. 1100 Powering and Grounding Sensitive Electronic Equipment

E. International Electrotechnical Commission (IEC):
   1. 60068-1 International Electrotechnical Commission
   2. 801-2 Electrostatic Discharge

F. National Electrical Manufacturers Association (NEMA):
   1. NEMA 5 Receptacle Classification

G. National Fire Protection Association (NFPA):
   1. 70 National Electric Code (NEC)
   2. 75 Standard for Protection of Electronic Computer/Data Processing Equipment
3.  

101 Life Safety Code

4.  

130 Standard for Fixed Guideway Transit and Passenger Rail Systems

5.  

R1-2 General Purpose and Communication Battery Chargers

H. Underwriters Laboratories, Inc. (UL):

1.  

1449 Safety Standard for Surge Protective Devices

2.  

1778 Standards for Uninterruptible Power Supply Systems

1.03 SYSTEM DESCRIPTION

A. Design, provide, install and test Alternating Current (ac) and Direct Current (dc) power supplies for communication equipment in communications facilities and Distribution Cabinets (DC) as described in the Specifications.

B. Provide and install all power distribution related cables in accordance with the Specifications.

C. Provide and install grounding for all power supply equipment in accordance with the Specifications.

D. Surge Arrester and Surge Suppression equipment size, type, installation and connection shall be in accordance with the Contract Drawings, NEC and CEC.

E. Configure each UPS network and alarm configuration settings to report UPS and other subsystems’ alarms (sensed by UPS dry contact inputs) to the CCF UPS Alarm Monitoring System. Coordinate with the Engineer end-to-end testing and reporting of such alarms at CCF.

1.04 SUBMITTALS

A. Refer to Section 17000, Basic Communications Technical Requirements, for related and additional submittal requirements.

B. Preliminary Design Technical Requirements: Include the following information as part of the PDR submittal package for the Power Supplies and Distribution:

1. Manufacturer Data Sheets for Uninterruptible Power Supply (UPS), including batteries, battery charger, transformer, transfer switch, inverter and converter.

2. Manufacturer Data Sheets for DC Power Supplies.

3. A description of the power supply for each equipment site, including pertinent parameters from below:

   a. Configuration including dimensions, plan and elevation

   b. Power draw
c. Standby time

d. Battery dimensions and weight

e. Short circuit rating

f. Voltage

g. Continuous Current

h. Interrupting Ratings

4. Schematic diagram of UPS components including, but not limited to the ac to dc converter, batteries and battery charger, inverter, transformer, transfer switch and ground connections.

5. Caltrain LAN Network and software configuration settings for UPS for communications with the existing Caltrain UPS Alarm monitoring head-end at CCF. UPS internal software alarm configurations and settings. UPS dry contact software and hardware configuration for external subsystem’s alarms sensing and reporting.

6. Drawings showing the layout and rack mounting details of the Power Supply and UPS equipment.

7. Detailed drawings of connections to Main Grounding Buss-bar (MGB) showing routing of ground wires and mechanical details of connections.

8. Single line diagrams for Communications Equipment Room (CER) and Distribution Cabinets (DC) and station field wiring.

9. Calculations for each power supply demonstrating the capability of the proposed equipment to adequately serve the load demands of the connected equipment:

   a. Submit ac and dc power calculations based on the total peak and nominal load for each communications equipment and power distribution board.

   b. Nominal load is defined as the load for normal operation. Include 50 percent factor for future expansion.

   c. Derive load by showing power consumption of each type of device in each location (communications room and at each station distribution cabinet).

   d. Identify a nominal load for each UPS based on normal direction operations.

   e. Voltage drop calculations between the communications room and distribution cabinet panels.
f. Calculations showing that the UPS electrical size can meet the peak load (including additional 50 percent capacity for future growth).

g. Calculations showing that the UPS battery capacity can sustain the nominal UPS load plus 50 percent (for future growth) for a period of 90 minutes.

h. Structural and Seismic calculations for UPS, batteries and Power Distribution equipment mounting based on the dimensions and weight of the proposed components.

i. Calculations shall be signed/sealed by appropriate Professional Engineer licensed in the California.

C. Final Design Technical Requirements: Include the following information as part of the FDR submittal package for the Power Supplies and Distribution:

1. Updated PDR information. All drawings, calculations and design shall reflect a final design.

2. Final and detailed wiring drawings ready for construction and installation.

3. Final equipment list.

4. Final equipment installation details.

5. Final cable and equipment ID.

D. Installation Plan: Submit the following installation document for each site no later than 60 days prior to the scheduled installation activity:

1. Step-by-step plan for installing each piece of equipment, interconnecting raceway and cabling details, including estimated time required for the installation.

E. Calculations and Certifications:

1. Calculations as listed in the Preliminary Design and Final Design.

2. Certifications: Copy of the following certifications shall be included:
   a. ISO certification for all proposed manufacturers

F. Product Samples: Submit and demonstrate product samples when requested by the Engineer.

G. Test Plan and Procedures: At least 30 days in advance of testing, submit Test Plan and Procedure. Include tests to be made, format and layout of the test forms and report, and the limiting values to be used. In accordance with the format and requirements described in these Specifications, as a minimum, submit the following plan and procedures to satisfy the Power Supplies and Distribution testing requirements.
1. Test program plan: Include all the required information for the communications Power Supplies and Distribution in the Test Program Plan as outlined in these Specifications.

2. Factory and Inspection Test Procedure: Submit a complete factory test and inspection procedure to satisfy requirements outlined under “Testing” herein.

3. Field Test Procedure: Submit a complete field test procedure to satisfy requirements outlined under “Testing” herein.

4. End-To-End Acceptance Test: Coordinate with Caltrain Engineering and perform end-to-end testing of each UPS’s internal software and external subsystems’ dry contact alarm reporting at CCF UPS Alarm monitoring software head-end.

H. Test Records: Submit the Test Records and Results for review one week after the completion of each test, in accordance and format in these Specifications.

I. Manufacturer Qualifications: Submit qualifications for any manufacturer differing from those specified herein and obtain Engineer’s prequalification and approval. Acceptability of the manufacturer shall be based on the manufacturer’s experience, qualifications, certifications (i.e. ISO-9001), equipment reliability, compliance with standards specified herein, and full compatibility with Caltrain’s existing systems.

J. As-Built Documentation: Submit complete As-Built documentation (including equipment O&M manuals and UPS final network, software and hardware configuration settings) and drawings, as specified in Section 17000, Basic Communications Technical Requirements, for communications Power Supplies and Distribution.

1.05 QUALITY ASSURANCE

A. Contractor’s fabrication, inspection, installation and testing shall comply with all applicable Standards and Codes as listed herein. All equipment and methods shall comply with the latest version of the standards as applicable in paragraph 1.02, Reference Standards.

B. Material and Workmanship Requirements:

1. All equipment provided under this Section shall be UL listed.

2. All grounding and lightning/surge protection equipment shall be in accordance with local standards and these specifications except as modified herein. Each piece of equipment shall be grounded and protected in accordance with the recommendations of the manufacturer.

3. Use not discontinued product models, refurbished equipment, products at their end-of-life, end-of- sale, or end-of-service.
4. All products specified herein shall be subject to the Engineer approval based on the Contractor’s ability to demonstrate adherence to the specified requirement and Engineer’s approval of the manufacturer’s quality process.

5. Any manufacturer differing from those specified herein shall require the Authority prequalification and approval. Acceptability of the manufacturer shall be based on the manufacturer’s experience, qualifications, certifications (i.e. ISO-9001), equipment reliability, and compliance with standards specified herein, and full compatibility with the Caltrain’s current system.

PART 2 - PRODUCTS

2.01 GENERAL DESIGN REQUIREMENTS

A. Uninterruptible AC Power Supply:

1. This type of power supply shall be utilized to provide conditioned ac power to equipment during normal operation and to provide temporary backup ac power in case of a failure of normal ac.

2. UPS shall be provided at Communications Equipment Room (CER), and extended to each subsystem Distribution Cabinet (DC).

3. Batteries shall provide 90 minutes of backup power at all station communication essential subsystems, and devices (i.e. WAN/LAN equipment, PA, TVM, Clipper Equipment, CCTV, VMS signs, etc.). Station non-essential devices such as maintenance power outlets, cabinet lighting, etc. shall be powered by non-UPS backed power.

4. The UPS shall be initially sized for full system load plus 50 percent future capacity.

5. UPS shall be equipped with by-pass switch of mechanical or solid state type, which shall provide automatic failover to the ac power source in the event of UPS output failure. Ac power source shall remain available, even if there has been a short in the UPS. The by-pass switch shall isolate the UPS rectifier and inverter components for replacement or service.

6. Manual Bypass Switch: In addition to the automated by-pass switch, a manually operated bypass switching arrangement shall be provided to permit transferring the essential loads to the alternate power source, without interruption of power and at the same time to electrically isolate the UPS for maintenance purposes. Such maintenance bypass switch shall be electrically interlocked to prevent, back feeding the UPS output in the event of incorrect operation, e.g. transferring the load to bypass switch when the load supplied by the inverter.

7. UPS shall initiate an audible alarm upon activation of the automated or manual by-pass. The audio alarm shall be capable of being muted by the user. The alarm shall continue to sound while in by-pass mode. This shall
provide reminder to the user that load continues to be powered from utility or generator supply alone.

B. Dc Supply:

1. DC supplies (24Vdc) (and, if required, other power supplies) shall be provided and installed for Clipper CID devices, Media Converter and/or other devices (as required by the Contractor’s design approved by the Engineer).

2. Power supplies shall provide DC power to equipment during normal operation. All dc power supplies used for communications equipment shall receive power from a UPS power source.

C. Ac Power Supply:

1. Primary ac power for the Communications Equipment Room (CER) shall be provided either from a Station Electrical Panel.
   a. One 208 Vac, 3 phase circuit (or, if necessary, as per the Engineer approved alternative power source) appropriately sized shall provide power to the CER’s UPS (line side).
   b. AC power distribution within the CER and Station for subsystems shall be in accordance with Contract Drawings.

2. AC Power for Station subsystem Distribution Cabinets (DC) shall be provided from the CER’s UPS (equipment side) and distributed as shown on the Contract Drawings.

Provide and install all required cables, distribution panels and connections between the CER’s UPS electrical enclosure panel and the Distribution Cabinets.

D. Grounding:

1. Equipment within the CER and Distribution Cabinets shall be grounded to the communications MGB and CGB respectively, independent of the power supply ground or neutral connections.

2. The safety ground for UPS shall be bonded to the building MGB via the communications MGB to provide a single point earth ground.

2.02 UPS SYSTEM

A. Each UPS system shall be sized to handle 150 percent of the station connected load (initial “day-one” load plus 50 percent spare for future growth). The backup time shall be 90 min for such load.

B. Each UPS shall include a Ferro resonant transformer, battery float charger, batteries, static inverter, and microprocessor controlled switch circuitry.
1. The load shall normally be powered from the secondary of the Ferro resonant transformer; the primary of the transformer shall normally be powered from one of 120/208/240 Vac, 60 Hz sources from a station electrical power panel.
   a. Manual bypass switch shall be provided and installed for the UPS such that the load can be powered from the normal source for maintenance without service interruption.
   b. Manual ac Disconnect Switch shall be provided to facilitate disconnecting the equipment for maintenance service.
   c. In the event of a UPS failure, the load shall revert to the normal ac source (even if that source is unavailable).
2. The static inverter shall normally be off, but shall be switched on automatically upon detection of a failure or irregularity in the normal power input and shall then supply power to the transformer primary. The batteries shall power the inverter.
3. The batteries shall be maintained at full charge by the battery charger. The battery charger shall be powered from the normal ac source in parallel with the transformer primary.
4. The microprocessor controlled switch circuitry shall monitor the ac input and output and the dc voltage and current levels. Switching from normal to battery power and back to normal shall be automatic and shall not affect output voltage and current waveforms.

C. Each UPS system shall provide power quality consistent with the equipment connected. In addition, the UPS shall meet or exceed the following specifications:
1. Input Voltage: 240/120 Vac (if approved by Engineer, 480 Vac), Nominal
2. Output Voltage: 120 Vac, Nominal
3. Voltage Regulation: ±3 percent with input 96Vac to 138 Vac
4. Spike Attenuation: 2000:1 (up to 6000 V and 200 A)
5. Noise Attenuation: 120 dB Common Mode, - 60 dB Transverse Mode
6. Output Frequency: 60 ± 0.005 Hz
7. Waveform Type: Sine wave
8. Input ac Overload Capacity: 125 percent Rated (10 Min), 150 percent (Surge)
9. Output Waveform Distortion: 3 percent (Max) Single Harmonic, 5 percent Total Harmonic Distortion
10. Operating Temperature: 0 degrees to 40 degrees Celsius

11. Operating Humidity: Up to 95 percent Relative Humidity (R.H.)

12. Line Powered Efficiency: 88 percent average with a minimum of 90% efficiency above 50% load.

13. Audible Noise: 51 dBA at 1 meter from the UPS surface.

14. EMI Suppression: The UPS shall meet the FCC rules and regulation 47, part 15, subpart J, for class A devices

15. Mean-Time-Between-Failures: 100,000 Hours

16. Transfer time from line power to internal battery: 3-4ms

17. The UPS system shall be equipped with intelligent battery management. This shall include remote management, alarm notification, dry contact alarm input sensing and environmental monitoring capability. The management system shall support SNMP protocol. The management system shall utilize a networking card configured for reporting sensed alarms to the CCF UPS Monitoring head-end over the Caltrain network.

D. Transformer: The Ferro resonant transformer shall provide complete isolation from input to output. It shall be rated for continuous supply of 140 percent of the maximum draw of the communications equipment with input voltages in the range 96 to 138V.

E. Inverter: The inverter shall utilize all solid state components and be rated for 140 percent of the continuous output required such that the transformer coupled output, as specified above, shall be realized when the inverter is on. There shall be no interruption of service to the load when the inverter is switched on or off.

F. Batteries: The battery shall be a multi-cell bank composed of sealed maintenance free cells. The battery bank shall be rated to provide power to the inverter such that 140 percent of the current draw of the protected equipment can be provided upon complete failure of the ac input for a period specified in under "Uninterruptible ac Power Supply herein. The battery life shall be at least 200 charge/discharge cycles and 10 years.

G. Battery Charger: The battery charger shall utilize all solid state components and shall be rated to fully charge the batteries within four hours from a fully discharged state while the normal load is connected. The battery charger shall include automatic tapering and floating controls.

H. Microprocessor Control: The microprocessor control and switching circuitry shall continually monitor the ac input voltage, current, and frequency. If one of these parameters is outside the range where the output voltage or frequency remains within the specified tolerances, the inverter shall be switched on-line within eight milliseconds and the ac line disconnected. If the AC input comes back within range, the inverter shall be disconnected and the ac line re-connected automatically.
I. Light Emitting Diode (LED) indications for the following shall appear on the front panel of the unit: ac Line, Ready, Charging, Battery Power, and Alarm. In addition, the following functions shall be available on a keypad with Liquid Crystal Display (LCD) that shall be mounted on the front panel of the UPS, plugs into a diagnostics output port and are also functions of the TCP/IP SNMP monitor:

1. Meter Functions:
   a. Ac Volts Output
   b. Ac Volts Input
   c. Battery Voltage
   d. Ac Current Input
   e. Ac Current Output
   f. VA Load
   g. Dc Current Input
   h. Frequency
   i. Heat Sink Temperature
   j. Projected Run Time Available
   k. Log of Power Outages and Alarms

2. Alarm Messages:
   a. Low Battery
   b. Near Low Battery
   c. High Battery
   d. Low Run Time
   e. Low ac Output
   f. High ac Output
   g. Output Overload
   h. Ambient Temperature High
   i. Heat Sink Temperature High
   j. Transformer Temperature High
k. Check Battery
l. Check Inverter
m. High ac Input
n. Alarm Test
o. Detection and reporting of other subsystem's alarms reported through dry contact input terminals

3. Operating Modes:
   a. Off
   b. Automatic
c. Line Conditioning
d. Inverter On

4. Set Operating Parameters:
   a. High ac Voltage
   b. Low ac Voltage
c. High Battery Voltage
d. Low Battery Voltage
e. Near Low Battery
f. High Ambient Temperature
g. Frequency Tolerance
h. Battery Capacity (run time)

J. Relay Alarm Contacts: Each UPS shall include two sets of alarm contacts (2 NO and 2 NC) rated at 125 Vdc and 1 Amp. The following outputs shall be programmed for future reporting of UPS alarms to the future Remote Terminal Unit (RTU) equipment, at the corresponding Communications House or Facility.

1. UPS Trouble: This relay shall change state when any of the parameters listed above move beyond the pre-established range. In addition, any faults with the battery chargers, batteries, or inverters shall cause this alarm to activate.

2. Loss of Primary ac: This relay shall change state when the primary AC power is lost and reset when it is restored.
2.03 DC POWER SUPPLIES

A. Communications Cabinet:

1. When applicable, 24V dc power (i.e. Clipper CID devices, Media Converters, etc.) shall be provided in the following configuration:

Two power supplies each sized to provide 100 percent of the maximum design load, which shall be 125 percent of the actual load. Each power supply shall power an individual fuse and be located in each communications cabinet requiring dc power.

B. The DC Power Supplies shall be powered by the UPS backed supply, as identified in the Contract documents.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Each power supply, including batteries shall be provided and installed as shown on the Contract Drawings.

B. All cabling from the power supplies to communications equipment and the power panel shall be routed as Engineer approved and so as not to interfere with other cables or equipment.

C. All cabling from the AC breaker panel to the power supply, where both are located within the same building, shall be installed within Electrical Metal Tubing (EMT) conduit.

D. Install DC and uninterruptible power supply equipment as recommended by the manufacturer, and provide anchorage / seismic supports and restraints in accordance with the requirements as specified in these Specifications and as per Engineer approved Design.

C. Grounding:

1. General Equipment Grounding: Within each Communications Equipment Room (CER) and Distribution Cabinet, the power supply shall be grounded to the CMGB and CGB per this Specification. A power source neutral lead shall not be used as a ground.

2. Power Supply Grounding: The safety ground for all UPS and power supplies shall be bonded to the CMGB or CGB per these Specifications and the Contract Drawings.

3.02 EQUIPMENT MOUNTING

A. Cabinets and Racks:

1. The UPS components, exclusive of batteries shall be mounted within a freestanding cabinet with removable panels. The cabinet shall include a ventilation opening for convection cooling such that the unit shall...
operate within the specified temperature range. The cabinet shall have an enamel finish, in a color that shall be Engineer approved.

2. Equipment racks for mounting 19 inch EIA Standard equipment shall be in accordance with these Specifications.

3. Install uninterruptible power supply equipment at locations indicated with the top of the monitor panel not more than 6 feet above the floor and the bottom not less than 12 inches above the floor, unless specifically indicated otherwise. If necessary, line up tops of trims to present neat appearance.

4. UPS Systems mounted in 19 inch two post racks shall require additional support at the end of the system not bolted into the rack. Where necessary, angled braces shall be utilized (as per approval of Design by the Engineer).

B. Battery Racks: The batteries shall be mounted in a rack, or as recommended by the battery manufacturer. The battery rack shall be made of channel steel with an acid resistant gray paint finish. The battery racks shall allow access to all battery terminals without removing batteries from the rack.

C. Power Plug Mold Strip - Equipment Cabinets: Provide the required sized and rated UL power plug mold strip in each equipment rack or cabinet. The power plug mold strip shall be powered from the UPS Ac source that is shown on the Contract Drawings. The plug mold strip shall be mounted vertically in the cabinet and contain a minimum of 10 power outlets.

D. Standard (non-UPS) Power Source - Equipment Cabinets:

1. Quad receptacles home run from the non-UPS Ac power source shall be installed in equipment racks or cabinets to provide access for non-essential or battery powered equipment such as test equipment or laptop computers.

2. One, 120Vac, 20A, duplex receptacle will be provided from the non-UPS ac power source to each communications cabinet for general purpose use.

E. UPS Receptacle Type:

1. One, 120Vac, 30A, duplex receptacle rated NEMA L5-30R (twist lock) will be provided in each field communications cabinet for UPS to be used for communication equipment use only (not for general purpose use).

2. One, 120Vac, 30A, duplex receptacle rated NEMA L5-30R (twist lock) will be provided for each CER communications equipment rack or cabinet for UPS to be used for communication equipment use only (not for general purpose use).

F. Grounding Wire: Ground wire shall be a minimum of No. 6 AWG, or as specified on the Contract Drawings, stranded copper wire with insulating jacket. The insulation shall be rated for 600V minimum, and shall be colored green.
G. UPS Distribution Panels: 120Vac UPS Distribution panels will be placed throughout the station per the Contract Drawings to distribute UPS power to assigned subsystem equipment. These panels will be typically rated at 100A to 225A (rated as per the Engineer approved Design power calculations) with 16 to 30 breaker positions. UPS Distribution panels will be fed from the UPS Main Distribution Panel located in the CER.

3.03 TESTING

A. Testing of each power supply shall be conducted in accordance with these Specifications. Tests shall verify the following:

1. Output Power Levels
2. Output Quality
3. Transfer of load to standby source
4. DC equipment holdup in the event of single rectifier failure
5. Backup power holdup times under full load with commercial line power removed
6. Accuracy of all meters
7. Proper grounding and protection connections and levels
8. Functionality of all alarms, indications, and controls
9. All Station systems functions which depend on the UPS shall be tested while the UPS system is operating on the backup battery 15 to 30 minutes after the UPS has switched to its battery source.

B. Provide all instruments, materials, and labor required for tests specified.

C. Follow the test equipment manufacturer's instructions as to operation and electrical connections.

D. System Integration Test (SIT): Provide qualified staff to support this test as described. SIT will be directed by the Engineer. SIT requirements for power systems are generally related to integrating power system alarms.

END OF SECTION
SECTION 17750
VISUAL MESSAGE SIGN

PART 1 – GENERAL

1.01 DESCRIPTION

A. Section includes requirements for a Visual Message Sign (VMS) for passenger stations as a subsystem of Caltrain station communications.

1.02 REFERENCE STANDARDS

A. National Fire Protection Agency (NFPA):
   1. 70 National Electrical Code (NEC)

B. Telecommunications Industry Association/Electronics Industries Alliance (TIA/EIA):
   1. 568-B Commercial Building Telecommunications Cabling Standard (including B.1, B.2, and B.3)
   2. 606-A Administration Standard for the Telecommunications Infrastructure

C. Americans with Disabilities Act (ADA):
   1. Federal Transit Administration 49 CFR Part 37 Appendix A

D. Department Of Defense Design Criteria Standard:
   1. MIL-STD-1472 Military Standards

E. Underwriters Laboratories (UL):
   1. UL-969 Standard for Marking and Labeling Systems

1.03 SYSTEM REQUIREMENTS

A. The Visual Message Sign shall provide a visual display of dynamic messages, including timetable, listing of arrival and departure times for trains; commuter rail delays, status, or travel updates; alternate service plan advisories; general safety and security advisories; construction activities and interruptions; marketing messages; and local events, emergency and security announcements.

B. Visual Message Sign equipment shall include matrix display signs with attached sunshades, cabling, and all other equipment defined in this Section and as shown on the Contract Drawings.

C. Each VMS shall be individually addressable from the Central Control Facility (CCF).
D. The VMS shall be capable of displaying both text or graphic images.

E. The VMS shall be readable under all lighting conditions, including direct low-angle sunlight. The intensity and brightness of the displays shall be automatically controlled by a compensation circuit that senses ambient light conditions.

1.04 SUBMITTALS

A. Refer to Section 17000, Basic Communications Technical Requirements, for related and additional submittal requirements.

B. Submit detailed catalog cut sheet including dimensions of the VMS.

C. Submit structural design, including drawings and calculations for tube steel support members and concrete footings with seismic zone 4 designs, signed and sealed by a Structural Engineer licensed in the state of California.

D. Submit installation drawings no later than 14 days prior to installation of the VMS. Proceed with the installation only after the Engineer approval of installation drawings.

E. Testing: Submit test plan and procedures at least two weeks prior to commence of testing the VMS. Submit, within 15 days after conclusion of system testing, a report of final Test Procedures and the Results obtained from these tests.

F. As-Built Documentation: Submit complete As-Built documentation and drawings, as specified in Section 17000, Basic Communications Technical Requirements, for VMS equipment.

G. Operation and Maintenance Data: Provide documentation containing complete details of the delivered VMS equipment including operating and maintenance procedures and manuals.

1.05 SOURCE QUALITY CONTROL

A. The functional tests shall fully exercise the system and determine functional compliance as follows:

1. Test each electronic component of the VMS prior to shipment to the project site. Test results shall be submitted for Engineer approval.

PART 2 – PRODUCTS

2.01 VISUAL MESSAGE SIGNS (VMS)

A. Each VMS shall be individually addressable from the assigned CCF for sending information, configuring memory, and for investigating the contents of memory.

B. The VMS at the station shall be operable either from the assigned CCF or a local input device connected directly to the VMS.
C. Locally generated visual messages shall take priority over the assigned CCF generated messages.

D. The VMS shall be capable of displaying both text or graphic images on a large bright screen of high intensity light emitting diodes (LED). The display shall have the following characteristics:

1. Visual character heights
2. Automatic intensity control
3. 30 degrees from center axis
4. Multiple fonts
5. Multiple display effects; flash, scroll, roll, graphics
6. One to multi-line text

F. Each VMS shall be capable of storing 32 preprogrammed messages.

G. The VMS shall automatically lower its peak intensity in concert with ambient light conditions. Adjustment shall range from 25 percent level to 100 percent level.

H. The VMS shall be equipped with manufacturer’s standard sun shade.

I. VMS systems shall be supplied in single or double sided configuration as required by the Station design. Single sided VMS shall have the same display characteristics as the double sided described in this Section.

J. Supply double-sided visual message as shown on the Contract Drawings. The double-sided message boards shall be Daktronics Model Galaxy AF-6300 Part No. AF-6300-32X192-8-A-DF or Engineer approved equal. Each VMS shall conform to the following:

1. Display Characteristics:
   a. Luminance: amber – 4,000 cd/m² (Nits) brightness
   b. Effects: flash, scroll, travel, roll, split, graphics
   c. Character height: variable
   d. Messages: multi and single line, minimum requirements of 2-lines of text, each line a minimum of 4" high and legible from 200 feet to meet ADA Standards for Transit Facilities.
   e. Viewing angle: 30 degrees to either side of perpendicular

2. Physical Characteristics:
   a. Enclosure: NEMA 4X
b. Enclosure length: 62.5 inches maximum

c. Display window: shatter-proof, vandal resistant, ultra-violet resistant, condensation prevention

d. Metal components: corrosion resistant

e. Maintenance access: access doors on each side of double-sided sign

3. A computer cable port shall be included to allow local messages to be generated via a laptop computer.

J. Cables: Cables shall conform to the requirements of Sections 16100, Wiring Methods, and 17120, Communications Wires and Cables.

K. Network Connectivity: The VMS shall come equipped with a factory installed 10/100 Mbps Ethernet to serial converter with a standard RJ-45 port or fiber optic interface port for connection to the Station LAN equipment.

L. The VMS system shall be compatible with Daktronics Model Venus 1500 display control system software.

M. Extend Caltrain’s current Venus 1500 VMS software license from Daktronics with the Enterprise license extension for each new VMS display provided.

M. The VMS displays shall be powered by Uninterruptable Power Supplies to prevent loss of emergency passenger communications for 90 minutes.

N. Mounting: Provide the VMS mounting as shown on the Contract Drawings, including all foundation work, stanchions, mounting brackets, and bracing.

N. Stanchions used for VMS mounting shall have an installed full-length divider to separate communication wiring from power wiring, or internal flex raceway for communication wiring.

2.02 EQUIPMENT RELIABILITY

A. All VMS equipment shall have a Mean Time Between Failures (MTBF) of at least 100,000 hours.

B. Maximum time to repair or restore the VMS provided shall not exceed one hour (from arrival of a maintenance technician at the site of the fault or failure) in the event of fault or failure of any subsystem or physical unit excluding cabling which runs in conduit. Equipment availability shall be such that only one side of one VMS sign is inoperative at any given time.
PART 3 - EXECUTION

3.01 INSTALLATION

A. All materials and installation necessary to complete the VMS System work shall conform to the requirements of the applicable standards and in accordance with the manufacturer's recommendations.

B. Provide complete electrical and mechanical design for the installation of the VMS equipment.

C. Provide necessary conduit and wiring, both power and data, to complete the VMS installation. Where two or more VMS are connected to the dual Ethernet switches at the same DC (Distribution Cabinet), for redundancy, connect odd number VMS to first Ethernet Switch and even number VMS to the second Ethernet switch.

D. Verify that all equipment is the appropriate model, properly installed and connected in accordance with the Contract Drawings. The quality of the installation shall be demonstrated by tests for continuity, visual inspection and any other tests required by this Section.

E. Install VMS stanchions, including pole, support arms, and foundation, as shown on the Contract drawings and as specified in the Contract Specifications.

F. Mount VMS on stanchions. Verify that all mechanical connections are made and secure.

G. Apply all IP addresses to the VMSs as required by Owner’s network standards and recorded in the network Domain Name Server. All IP addresses shall be issued by the Caltrain IT network administrator. If required by the Caltrain administrator, implement VMS VLAN.

H. Perform startup of the VMS.

3.02 VMS INSTALLATION FOR STATIONS

A. Mount enclosures on tube steel support members. Locations are shown on the Contract Drawings. Mounting hardware and mounting arrangement shall be in accordance with Contract Drawings and manufacturer's recommendations. The VMS shall be secured and plumbed, and clearly viewable by the passengers.

B. VMS support columns shall be securely attached to concrete footing.

C. Mount VMS to provide a minimum 8 foot 2 inch vertical clearance and a maximum 9 foot from the platform floor to the bottom of the VMS.

D. The end of the VMS sign shall not extend beyond the horizontal arm of the support pole in the direction of the tracks.

E. The VMS shall be mounted to the support pole to meet seismic zone 4 code.

F. Repair any damage done to existing equipment (e.g. supports, wires, or similar items) to the satisfaction of the Engineer.
3.03 CABLE INSTALLATION AND TERMINATIONS

A. Cables in Conduits:
   1. Verify that communications conduits have been inspected and cleaned prior to cable installation. Conduits shall have a clean, smooth concentric interior surface.
   2. Crossover of cables shall be avoided when cables are pulled into conduits. Care shall be taken not to have the conductors pulled tight or twisted in conduit fittings or boxes. All cables to be installed in a single conduit shall be pulled simultaneously.

B. Verify that all cables are properly routed, supported, terminated and labeled.

C. Wires and cables shall be continuous without splices between junction boxes, terminals, pull boxes, manholes and hand holes.

D. Terminate the cables installed between the VMS and the communications cabinets. The termination shall allow quick disconnection of the VMS.

3.04 FIELD TESTING

A. Perform tests in accordance to the Engineer approved test plan and procedures.

B. Field tests shall include functional and operational tests of equipment for all message features from the CCF as well as at the station.

C. The functional tests shall fully exercise the system and determine functional compliance as follows:
   1. Perform end-to-end tests for every control and indication point.
   2. Verify that all equipment is installed in its proper location in accordance with the approved design. Verify that all mechanical and electrical connections are made and secure.

D. Perform the following Operational tests:
   1. Verify full functional communication between the CCF and each of the existing stations.
   2. Verify all features are available at each of the Control Consoles at the CCF and they work as specified with the station.
   3. Verify on each VMS the display of the CCF generated messages at the station.
   4. Verify on each VMS the display of messages generated on a locally connected laptop computer at the station.
E. Perform integrated system testing to ensure full functionality with all existing systems of which the VMS is a part.

END OF SECTION
SECTION 17790
COMMUNICATIONS NETWORKS

PART 1 – GENERAL

1.01 DESCRIPTION

A. Section includes requirements for the Caltrain WAN/LAN network equipment and components required to connect station system and service to the assigned Central Control Facility (CCF) and Caltrain headquarters in San Carlos. The network shall be based on the TCP/IP suite of protocols.

B. Section also includes requirements for Clipper WAN/LAN network equipment and components required to connect station Card Interface Devices to the Clipper WAN.

1.02 CALTRAIN COMMUNICATIONS NETWORKS SYSTEM DESCRIPTION

A. In the station, provide new (or update the existing) data T1 service with serving speeds of up to a “full” T1 (1.544 Mbps) to connect the TVM/VMS/PA/CCTV to the Caltrain WAN (Wide Area Network).

B. Provide all necessary conduits, cables, and cabinets to interconnect the local communications provider MPOE (Main Point of Entry) to the station CER (Communications Equipment Room). Note that, in absence of CER, some Caltrain stations may still utilize outdoor Station Communications Cabinets (SCC) also sometimes referred to as Communications Interface Cabinets (CIC). It is the intent that the SCC's/CIC's be phased out and upgraded to CER's. In this Section, for simplicity, the terms “SCC” and “CIC” are omitted. The term “CER” is used instead and it covers all types of station central Communications equipment implementation.

C. Coordinate with the local communications provider in the design phase to setup the MPOE in the station under the local communications provider requirement.

D. Provide all necessary material, labor, and equipment to affect the frame relay service in the station.

E. Provide dual 1000 Base Managed Ethernet switches at each station CER to interconnect the router and all other network devices. The station CER Ethernet switch shall have minimum capacity of twenty-four 10/100 Base T/TX port (12 of which shall be PoE compliant) and four single-mode fiber capable GBIC-based ports. Each switch shall be sized for an adequate number of GBIC, 10/100 Base T ports and PoE enabled 10/100 Base T ports to service the required number of subsystem devices assigned, plus 50% spare ports. At the current stage, the Station design will not include the interconnection by a Caltrain wide area fiber network. However, the station CER Ethernet Switches shall have two (out of four) single mode GBIC expansion ports assigned and programmed as spare for this future wide area fiber network.

F. Provide Dual 1000 Base Industrial Managed Ethernet switches at each station distribution cabinet. Each switch will be sized for an adequate number of 10/100
Base T ports and PoE enabled 10/100 Base T ports to service the required number of subsystem devices assigned, plus 50% spare ports.

G. Use a single-mode fiber optic ring topology for all station 1000 BASE FX switch interconnectivity.

H. GBIC modules shall be provided for each GBIC-based port in the switch.

I. In a new station, furnish and install a router device with the necessary CSU/DSU (Channel Service Unit/Data Service Unit) and Ethernet module. The router shall interconnect the station network equipment in the station to Caltrain WAN. The router shall has minimum of four expansion slots with four built-in 10/100 Ethernet ports.

J. Dual 1000 Base (GigE) Ethernet switches shall be installed in the Communications Equipment Room (CER) and each field communications distribution cabinet per the Contract Drawings. Station CER and DC GigE switches shall be assigned to the single-mode fiber optic backbone and interconnected in a dual redundant physical ring topology. For redundancy, station field devices (such as TVM and VMS) serviced by these dual switches shall be divided into two groups: first group will be served by one distribution switch; the second group will be served by the second distribution switch. The dual switches shall be programmed in such way that, if one of them fails, field devices connected to the failed switch could be manually reconnected to the remaining (healthy) switch ports.

K. All switching networking equipment will be located in the station Communication Equipment Room (CER) and station distribution cabinets (DCs). Subsystem devices shall be serviced from the distribution cabinet using copper (TIA/EIA Category 6) cable. Where required by design, the subsystem devices shall be PoE powered by the switches over the Category 6 cables. Subsystem devices with integrated networking (switching) and direct fiber interfaces shall be serviced directly from the CER using single-mode backbone cable, eliminating the need for intermediate network electronics.

L. All network equipment, related protocol/media converters and any other active equipment connecting Station systems to the Station network require UPS-backed power, which shall be rated for provision of non-interrupted service for at least 90 minutes in the event of loss of utility power.

M. Provide any required stand-alone field media converter/switch for each subsystem device requiring protocol conversion. Interfaces and network topology for subsystems are described in Division 17 Specification Sections related to that subsystem. Fiber Optic Media converters and single-mode cabling shall be used when the Category 6 cable run to the subsystem device exceeds 300 feet from the serving Ethernet Switch in CER or DC (whichever is closer). If such subsystem device requires PoE power, the Media Converter shall support provision of 10/100Base-T with PoE output. For such applications, the single-mode runs shall be accompanied with power wiring delivering UPS-backed power to the remote Media Converter with PoE.

N. Wireless equipment to connect an extended range system device to the distribution cabinet where conventional UTP or fiber cable placement is not
possible shall be furnished and installed with Engineer’s approval. For example, where a required CCTV camera placement would exceed the cable distance limitations set forth in TIA/EIA 568-B, a wireless link can be used, with the Engineer’s approval.

O. Access requests to the Caltrain network require consultation with the Engineer; upon Engineer’s approval, provide a firewall router to access the Caltrain network.

P. Should network equipment specified herein become obsolete or should an upgrade model become available, replace the specified equipment with most current available model with Engineer’s approval. Submit full technical specifications for the replacement equipment for Engineer review prior to purchase.

Q. Test and make operational all specified equipment required to operate all communications subsystems in a station using the TCP/IP Ethernet network.

1.03 CLIPPER COMMUNICATIONS NETWORK SYSTEM DESCRIPTION

A. Clipper station communications network is independent from Caltrain station communications network. Clipper establishes the frame relay service in a station to connect the Clipper WAN to the station Clipper CID (Card Interface Device) LAN. Clipper provides for the station CID Router, CID Ethernet Switches and CID devices (Caltrain provides for the CID poles and poles temporary covers). The typical design of the CID network is of traditional non-redundant star topology, which includes: CID Router at CER for WAN/LAN interface connected to the CER Ethernet Switch, which in turn utilizes station single-mode fiber backbone for connection to the CID Ethernet Switches placed within DCs. The CID Ethernet Switches within DCs provide for CID LAN connection to the adjacent CID card readers over Category 6 cabling, utilizing existing Category 6 patch panel equipment within DCs. The CID devices have to be powered by 24VDC power supplies installed within the DCs. The actual project Clipper communications network implementation may vary, see the project Contract documents for the Clipper network design requirements and implementation details.

B. Provide all necessary rack space, conduits, 24VDC power supplies, patch cords and cables to inter-connect the Clipper station communications network devices between MPOE (Main Point of Entry) to all station CIDs. Install all necessary poles and temporary pole covers. Note that, since Clipper communications network utilizes some of the Caltrain backbone cabling and patch-panel equipment, such Caltrain network equipment design shall accommodate these additional connections.

1.04 CALTRAIN COMMUNICATIONS NETWORK DESIGN REQUIREMENT

A. All network equipment shall be commercially available through multiple sellers or distributors. The manufacturers shall have implemented a standard Quality Assurance program such as ISO 9001 certification.

B. All network equipment shall include an SNMP agent for management. Management protocols supported shall include SNMP, RMON, and Telnet.
C. All network equipment shall have a minimum of five (5) years warranty from the manufacturer.

D. The network equipment shall be 19 inch EIA rack-mountable or DIN rail mountable.

E. All switches shall auto-detect full and half-duplex operation on all ports.

F. All switches shall support VLAN (IEEE 802.1Q), Rapid Spanning Tree Protocol (IEEE 802.1W), and Multiple Spanning Tree Protocol (IEEE 802.1S). The Ethernet dual redundant rings shall be configured for detection of failure and switchover to the healthy side of the ring within a few milliseconds of a failure.

G. The switch shall have embedded web-based management software with the ability to manage up to 16 switches at once.

H. No network equipment which has been retired from production, or reached End-of-Life, by the manufacture is acceptable for installation. Network equipment which has been scheduled for production End-of-Life shall be accepted only by Engineer’s approval.

I. All Ethernet switches shall be environmentally rated for operation within internal temperatures, vibration and shock, dust, surge and noise immunity ratings of the station CER and DCs.

J. All outdoor copper cabling connected to the CER or DCs switches shall utilize lightning/surge protection equipment at the point of entrance into those facilities.

1.05 SUBMITTALS

A. Refer to Section 17000, Basic Communications Technical Requirements, for related and additional submittal requirements.

B. Submit performance data descriptions or samples of all products furnished under this Section for Engineer review.

C. Submit application to the local communications provider and Engineer for the frame relay circuit, and PVC (Permanent Virtual Circuit) service in the station. The circuit shall meet the specification and requirement of the system in the station.

D. Submit shop drawings showing the details of interfacing the frame circuit from the MPOE to the station devices.

E. Submit network diagrams of the system including all interfaces and devices. Include specification cut-sheets for all proposed network components.

F. Submit the IP and VLAN addressing scheme for the station subsystems. The scheme shall be consistent with Caltrain network and assignment conventions.

G. Submit a Network list for all devices, showing proposed network addresses, subnets, gateways, mask assignments, VLANs and terminal address of each device.
H. Submit cabinet equipment vertical profile drawings depicting equipment placement in each cabinet. Submit thermo calculations showing that internal temperature of the cabinets will never exceed maximum allowed temperature ratings for the chosen switches and other network equipment.

I. Submit a complete bill of materials (BOM) for all network equipment and accessories.

J. Submit manufacture warranty documentations of all proposed network equipment described in this Section to the Engineer.

K. Submit a system cutover plan for approval no later than 30 days prior to the cutover.

L. Submit documentation to prove and demonstrate that the required steps prior to cutover specified in this Section have been completed seven (7) days prior to the cutover.

PART 2 – PRODUCTS

2.01 STATION ETHERNET SWITCH

A. The switch shall be furnished and installed in the station distribution cabinet. The switch shall be rugged switch designed for the harsh, rugged transit.

B. The switch shall be compliant with IEC-61850-3 and IEEE 1613 specifications for extended environmental, shock/vibration, and surge ratings; with a focus on redundancy; and convection cooling (no fans) with temperature ratings up to +60 degrees C (measured as continuous operating temperature range)

C. The switch shall be sized for an adequate number of 10/100 Base T ports and PoE enabled 10/100 Base T ports to service the required number of subsystem devices assigned, plus 50% spare ports.

D. The switch shall be equipped with at least two Single-mode GBIC modules.

E. The switch shall support IEEE Rapid Spanning Tree (802.1W) and Multiple Spanning Tree Protocol (IEEE 802.1S) for high resilience redundant fiber backbone connections.

F. The switch shall support PVST layer 2 load sharing on redundant ring links.

G. The switch shall support VLAN trunking protocol and 802.1Q.

H. The switch shall be the Cisco CGS-2520 series or Engineer approved equal.

2.02 STATION AGGREGATION ETHERNET SWITCH

A. Provide dual aggregation switches in the station CER. Each switch shall be connected to the Station LAN Ethernet switch using two GBIC-based ports via a Single-mode fiber ring topology (with additional two single-mode GBIC-based ports programmed as spare for connection to future Caltrain fiber WAN network).
B. The switch shall be sized for an adequate number of 10/100 Base T ports and PoE enabled 10/100 Base T ports to service the required number of subsystem devices assigned, plus 50% spare ports.

C. The switch shall be equipped with dual power supplies with hot swap capability and automatic failover.

D. The switch shall provide for routing and uninterrupted performance at Layer 2 and Layer 3.

F. The switch shall provide for ability to upgrade uplink bandwidth to 10 Gigabit Ethernet.

G. The switch shall provide for multitude of redundancy features, such as 1:N master redundancy; network resiliency and redundant fiber backbone connections through Rapid Spanning Tree IEEE Protocol (802.1W), etc.

E. The switch shall be the Cisco Catalyst 3750 series or Engineer approved equal.

2.03 STATION ROUTER

A. Router shall be a rack-mountable.

B. The router shall be a highly reliable with IP LAN connection and proper WAN interface module.

C. The router shall have two high speed Ethernet ports or modules.

D. The router shall be equipped with a minimum of 2GB memory to support remote and local VLAN's and required security configurations.

E. The router shall be equipped with dual power supplies with hot swap capability and automatic failover.

F. The router shall be CISCO 2900 integrated services or 3900 integrated services series or equal. Router is dependent on the type of network interface (T1, DSL, ADSL, OC3) used.

2.04 GBIC MODULES

A. The GBIC modules shall be furnished and installed to connect among the Station Aggregation Ethernet Switch and distribution Ethernet switches

B. The GBIC modules shall meet or exceed the following specifications:

1. Support VLAN (IEEE 802.1Q), Rapid Spanning Tree (IEEE 802.W) and Multiple Spanning Tree Protocol (IEEE 802.1S) protocols

2. Support Layer 3 routing

C. The GBIC modules shall be provided with LC type fiber connector or SC type fiber connector if the LC type is not available from any manufacture and with the permission of the Engineer.
D. The switch shall have Single-mode GBIC modules available for future Station to Station connectivity but not supplied under this contract. Data sheets shall be submitted.

2.05 FIREWALL ROUTER

A. The firewall router shall be optionally provided as require by the Station network design.

B. The firewall router shall have an integrated 4 port 10/100 switch.

C. The firewall router shall have a lifetime warranty from the manufacturer.

D. The firewall router shall be the Cisco PIX525 bundle 50 or Engineer approved equal.

2.06 MEDIA CONVERTERS

A. Media converters used to interface the single-mode fiber optic cable at the subsystem device will be placed in the distribution cabinet (DC) associated with that device per the site specific plans. Media converters for TVM, VMS, and CCTV subsystems shall be dual 10/100 Base FX port with automatic ring path switching protection.

B. For remote devices requiring PoE, Media Converters shall provide for an Ethernet 10/100Base-T ports with IEEE 802.3af PoE.

2.07 UTP CAT 6 DISTRIBUTION PANEL

A. The Cat 6 48-port UTP distribution panel in distribution cabinet shall meet the following Specification:

1. Qualified Cat.6/Class E

2. Permanent Link/Channel of TIA/EIA568B-2.1 Cat.6

3. ISO/IEC11801 2nd Edition

4. EN50173 2nd Edition

5. IEC60603-7

B. The UTP Cat 6 patch panel shall be LEVITON 48-PORT PANEL CAT6 BLK 3U or Engineer approved equal.

2.08 UTP PATCH CORDS

A. Patch cords shall be Category 6, factory made, and not spliced and terminated on-site. They shall come in non-resonant standard lengths of 6 or 7 feet.

B. The patch cords shall have strain-relief RJ-45 connectors. The patch cords shall be rated as a minimum, Category 6 unshielded twisted pair cabling, and shall terminate all eight positions of the connector.
2.09 FIBER PATCH CABLE
A. Patch cords shall be complete factory fabricated assemblies from manufacture’s standard product line. They shall come in standard lengths of 6 or 7 feet.
B. Patch cords shall be of the same Fiber Optic characteristics as the backbone cable.
C. The patch cords shall consist of flexible cable with either SC or LC compatible connectors (as required for particular application).
D. The patch cords shall comply with the requirement of TIA/EIA-568-B.
E. Patch cords used for single-mode fiber will be colored yellow.

2.10 CABLE MANAGEMENT
A. Cable guides shall be specifically manufactured for the purpose of routing cables, wires and patch cords horizontally and vertically on 19-inch equipment racks. Cable guides shall consist of ring or bracket-like devices mounted on rack panels for horizontal use or individually mounted for vertical use. Cable guides shall mount to racks by screws and/or nuts and lock-washer.

2.11 LCD CONSOLE DRAWER
A. Rack mount console used for programming the equipment shall be furnished and installed in station distribution cabinet for each station.
B. The rack mount console shall include a monitor, keyboard and touch pad.
C. The rack mount console shall meet or exceed the following specifications:
1. Compatible with most PS/2 or USB type of KVM switches, to match provided computer equipment.
2. Integrated KVM console (88 key keyboard and touch pad) in a 1U rack mountable slide-away housing
3. Rack mountable in 19” system rack (1U)
4. Built-in touch pad
5. Power Consumption: 120V~230V; 50Hz~60Hz
6. Monitor Resolution (minimum): 1024 x 768
7. Operating Temperature: 0° - 50° C
8. Metal enclosure
2.12 KVM SWITCH

A. Rack mount KVM switch used for programming the router, switch and other device shall be furnished and installed in station distribution cabinet for each station.

B. The KVM switch shall meet or exceed the following specifications:

1. Use of keyboard, monitor and touch pad to control up to eight computers
2. Multilevel password protection
3. Quick view scan mode for monitoring selected computers
4. Operating System-independent operation
5. Connected PC can be added or removed from the setup without powering off the KVM switch
6. Plug-n-Play monitor support
7. Video resolution up to 1900x1200
8. LCD, SVGA, VGA and multisync monitor support
9. Mouse and keyboard emulation for system bootup
10. No software required to operate
11. LEDs for easy status monitoring
12. Rack mountable in 19" (1U) system rack

PART 3 – EXECUTION

3.01 INSTALLATION

A. Topology:

1. Each station (node) on the network shall have a physical address (Ethernet address), and shall be assigned with a logical (e.g., IP) address or a terminal ID. Where required, it shall also be assigned to the corresponding VLAN.

2. Program the IP address and terminal address to each system device accordingly to the IP address scheme approved by the Engineer.

B. LAN cabling:

1. Ducts carrying LAN cabling shall be installed in accordance with TIA/EIA-569-B and properly grounded according to TIA/EIA-J-STD-607-A and MIL-HDBK-419A standards.
2. LAN cable shall be routed away from all sources of interference, including power lines, motors, radio interference, fluorescent lighting, and heavy machinery.

3. The LAN cable shall be installed in inner duct and routed via protected risers and overhead raceway. Network equipment shall be installed to provide sufficient immunity from all electromagnetic disturbances.

C. Tagging:

1. Wire and cable shall be permanently tagged as specified in Section 17120, Communications Wires and Cables. Network configuration records shall be created and maintained. Tag labeling and network records shall be in accordance with TIA/EIA-606-A.

2. All jacks shall be identified using permanently mounted white tags with permanent black 1/8-inch minimum height lettering.

D. Station network equipment installation:

1. Provide an Access Router (Cisco 2900 or 3900 series or equal) at the main distribution cabinet to interface the network carrier. Connectivity from the network carrier (MPOE) to the Access Router shall be made with new conduit and wiring.

2. A Cisco 4-port 10/100 Fast Ethernet switch WIC (WAN Interface Card) card shall be installed to provide LAN connection to existing VMS matrix display. Provide the necessary software and hardware upgrade on the router to support the new module.

3. Install and position the station network equipment in cabinets or racks as shown on the Contract Drawings.

4. Install and position the distribution network equipment in cabinets or racks as shown on the Contract Drawings.

E. Central and station circuit upgrade and installation:

1. Be responsible for installing the Frame Relay services at the station, and shall establish and provide facility for setting up the frame relay service MPOE.

2. Install and setup a T1 circuit in the station.

F. Provide all equipment necessary, including router, WAN Interface Card, CSU/DSU, wiring and conduit for the Station and Central Control WAN upgrade.

G. Assist Clipper personnel with installation, termination and testing of the CID network devices.

H. Be responsible for the recurring cost of the new circuit during the test period and before the system and station cutover.
3.02 SYSTEM CUTOVER FOR A NEW AND REMODELED STATION

A. Submit a detailed system cutover plan based upon the requirements in this Section and the construction sequencing and cutover schemes.

1. This plan shall include all phases, and describe in detail how the objectives of elimination of system down time, and minimization of system disruption will be accomplished.

2. The new frame circuit and system shall be made operational and tested alongside the existing system in the station before the cutover.

3. The detailed cutover sequencing and order of work shall be subject to the Engineer’s approval.

4. Plan shall take into account Work Window from 1 am to 4 am for the TVM LAN and Clipper LAN cutover work; plan shall minimize TVM and CID service disruption.

B. Steps Prior to Cutover: The following is a summary of the steps required to be completed and documented seven (7) days prior to cutover the TVM/VMS system:

1. The new circuit and private virtual circuit (PVC) provisioning at each station, including any network upgrade, shall be installed and tested.

2. All cabinets including the communication rack/cabinet shall be installed with proper grounding.

3. All cabinets including the communication rack/cabinet shall be equipped with protective electrical outlets.

4. The conduit from the Telco cabinet to the communication rack/cabinet shall be provided.

5. The fiber cables from the station distribution cabinet to the distribution cabinets shall be installed and tested.

6. The UTP or fiber cable to the TVM machines, VMS signs, and other devices shall be terminated and tested.

6. UTP and fiber cable test result shall be submitted to the Engineer.

3.03 OPERATIONAL TESTS

A. General: Perform all manufacturers recommended equipment and cable testing. Perform all available equipment built-in unit and communications paired tests. Exercise and demonstrate as operational all equipment configuration, management, and diagnostic functions.

B. For new station Router and the new Ethernet Switches, perform the following additional tests:
1. Verify proper routing of network data from the WAN to the appropriate Station LAN and Node. Verify that the sub-net design allows test data to appear only at the intended destination(s).

2. Measure maximum throughput from the WAN to each station load under normal operating conditions.

3. Measure maximum throughput from each Distribution cabinet to central racks/cabinet.

4. Test all router and switch ports (including spares) to assure complete functionality at installation.

5. Observe the switch and router operating systems for indications of port errors and report all error rates above the vendor recommended maximum.

C. Assist Clipper personnel with their testing.

D. For station with wireless infrastructure, perform the following tests for all wireless links:

1. Transfer a minimum of a 500-MB file through each wireless link.

2. Measure and record transfer speeds.

END OF SECTION
SECTION 17800
PUBLIC ADDRESS SYSTEM

PART 1 – GENERAL

1.01 DESCRIPTION

A. Section includes requirements for a Public Address (PA) system for passenger stations as a subsystem of Caltrain station communications, and that will function as an extension of the existing public address system network. These requirements are for standard Caltrain stations (center island platform or outboard platforms). For other applications (i.e. areas beyond station platforms, maintenance facilities, tunnels, multiple platforms, etc.) refer to the corresponding project additional specific requirements.

B. Coordinate and provide interfaces between the station Communications Equipment Room (CER) and the station PA subsystem. In absence of CER, some Caltrain stations may still utilize outdoor Station Communications Cabinets (SCC) also sometimes referred to as Communications Interface Cabinets (CIC). It is the intent to phase out the SCC's/CIC's and upgraded to CER's. For simplicity, the terms "SCC" and "CIC" are omitted. The term "CER" is used instead and it covers all types of station central Communications equipment implementation.

1.02 REFERENCE STANDARDS

A. Electronics Industries Alliance (EIA):
   1. EIA 160 Sound Systems
   2. EIA-101 Amplifiers for Sound Equipment

B. Sound Equipment (SE):
   1. SE-103 Speakers for Sound Equipment
   2. SE-104 Engineering Specifications for Amplifiers for Sound Equipment

C. National Fire Protection Association (NFPA):
   1. NFPA 70 National Electrical Code (NEC)

D. Local noise ordinances

E. Building Industry Consultant Service International (BICSI):
   1. Telecommunications Distribution Methods Manual

1.03 SYSTEM DESCRIPTION

A. The PA system shall be used to provide train destination information and emergency messages to passengers, employees, and emergency response personnel. Primary communication of announcements shall be from the assigned Central Operations to the station via existing leased T1 lines or privately owned carrier network. The new
PA system shall also provide the capability to broadcast locally generated announcements and remote dial-in telephone announcements by the Caltrain users. The new PA system shall be either a new PA system installation at the new Caltrain station or a replacement of the existing PA system at the existing station.

1. The primary objective of the PA System is delivery to the passengers adequate levels of intelligibility of PA announcements.

2. PA equipment shall include phone input processing circuits, power amplifiers, premixers / ambient noise compensators, speakers, local paging and ambient noise sensing microphones, cabling, conduit, and all other station oriented equipment defined in this Section and as shown on the Contract Drawings.

2. Unless otherwise indicated in the Contract Documents, the PA system equipment shall be located in the new Station Communication Equipment Room (CER) and on the Station Platform(s). This shall also include station conduit and cabling network associated with the PA wiring.

3. The PA system shall provide for remote monitoring of local PA dry-contact alarms via UPS digital I/O sensing and reporting these PA alarms to the CCF UPS Monitoring software (at later time, Caltrain may use such digital I/O alarms for reporting via future SCADA). The Station PA shall also support future remote monitoring of local PA alarms via TCP/IP protocol to the Caltrain SNMP Network Management System utilizing Network Management cards at the pre-mixer and amplifier equipment.

4. Support Engineer in testing the operation of PA system at the stations from Central Control Facility (CCF).

5. Use of any component or device, not expressly specified herein, that is required to implement the work, shall be subject to the Engineer’s approval of required submittals.

1.04 DESIGN REQUIREMENTS

A. General: Remote PA messages to the station shall originate from the CCF and from a dial-up line for the announcements over the phone by the Caltrain end users. At the station, the PA system shall announce these messages and, shall be capable of broadcasting locally generated announcements and messages.

B. Public Address (PA): There shall be one PA zone per each station platform. Depending on the quantity of the station platforms, the station shall be divided into one (one-platform station) or two (two-platform station) PA announcement zones. Each PA zone shall be served by the associated 2-channel amplifier and ambient noise sensing microphone. Each zone PA volume shall be increased/decreased according to the noise level measured by the corresponding ambient noise level microphone. All station PA measurements shall be performed at 5 feet above the floor level. The new PA system shall provide for the following measurements (measured at 95% of the station platforms):

1. The PA system shall provide intelligible output coverage at a levels 6 dB to 12 dB over measured ambient noise.
2. On station platforms the coverage shall be a uniform level of plus or minus 3 dB @ 1000 Hz Octave band.

3. The speech intelligibility of the PA system announcements (measured in STI-PA female index) shall be minimum 0.6.

C. Sound Level Adjustment: The PA system shall monitor the ambient sound level at the associated station area and automatically adjust the output level of the power amplifiers. The system shall also have the ability to automatically adjust the output of the system to meet day time and night time noise abatement requirements of local municipalities. It shall be programmed to filter out "clicking," "pitching" and any other unsettling sounds, which may occur during use of switches, push-to-talk buttons, rotation of volume controls and other potential similar origins. The PA system shall be programmed to eliminate positive feedback for all microphones used by the PA system. The system shall be programmed to implement timed hang-up function for any sources of PA announcements.

D. CCF PA messages: Messages from CCF will be communicated via DS0 leased (fractional T1) or privately owned telephone lines utilizing E&M messaging. The PA System shall be ready for the future VOIP implementation of the Caltrain communications system and shall be capable of accepting remote PA messages from CCF in following formats: a phone line input from the future IP-to-Analog Phone Gateway and/or audio line output from the future Station Control Unit computer.

E. Local PA messages: A push-to-talk microphone/handset shall be provided to enable the broadcast of local ad-hoc PA messages.

F. Cell/Public/Private Phone Messages: The PA system shall have the ability to broadcast ad-hoc PA messages via a cell, public, or private phone. To mitigate concern of "prank calls" to this line, a phone access device shall be implemented programmed with access codes given by Caltrain. The PA System shall be ready for the future VOIP implementation of the Caltrain communications system and shall be capable of accepting remote PA messages from cell, public, or private phone passed through the future IP-to-Analog Phone Gateway as a phone line input.

G. PA system shall implement message broadcast priority as follows: In-progress PA announcements shall be pre-empted according to the priority scheme defined below.

1. CCF PA: Top Priority
2. Local PA via push-to-talk microphone/handset: Second Priority
3. Cell/Public/Private Phone Messages: Third Priority

H. PA system shall have the ability to monitor the speaker loading of each output channel to determine if any speaker wire disconnects, breaks, wire grounding, speaker faults, or other speaker circuit changes have occurred and transmit an alarm via output dry contacts when a change is detected. Wire these dry contact outputs to the local UPS sensing inputs for transmission of this alarm information to CCF UPS Monitoring Software. In the future, these alarms will be wired to the Caltrain future SCADA system. The PA System shall also support secondary means of communications and transmission of such alarm/event information via its Ethernet network interface cards for the future SNMP based monitoring and control over the Caltrain LAN.
I. The CER UPS shall be programmed to monitor status of the PA System dry contact outputs wired to UPS inputs for reporting via the UPS networking cards such abnormal conditions to the existing Caltrain UPS APC Smart Monitoring system located at CCF. If necessary, the Contractor shall provide for data cabling interface between UPS networking cards and the station LAN.

J. All digital processor/digital mixer parameters shall be backed up via FLASH ROM, and not requiring battery backup. System configurations shall be capable of being stored for recall from any system presets from the front panel control, switch closure, via manufactures application software running under Windows O/S or scheduled from the internal real-time clock/calendar. If communication between the host computer and the digital processor/ digital mixer is lost, the unit shall continue to function with the last commands received.

K. The manufacturer’s software for remote configuration, performance monitoring, and alarm monitoring shall be acquired and tested. All functions shall be tested at the station sites as current station LAN installations permit. The software shall be able to remotely interface with the PA hardware via Ethernet and be able to:

1. Configure the mixer inputs, outputs, crossovers, and preset functions

2. Control the power output amplifiers gain

3. Be TCP/IP compliant to monitor equipment status via SNMP tools

4. Be TCP/IP compliant to receive equipment alarms via SNMP tools

L. Redundant Ethernet switch ports at the CER shall provision at least 100 Mbps for a separate PA Virtual Local Area Network (VLAN) to segregate the PA traffic from all others on the network.

M. The station PA VLAN shall share the station LAN 1000 Mbps Ethernet backbone bandwidth with other station subsystems. The station LAN 1000 Mbps backbone will operate in a physical ring topology via the station single-mode fiber optic cable.

N. For all locations where environmental control is not implemented, all equipment installed shall be treated as equipment exposed to the elements. The equipments’ design, materials, installation, mounting, termination and coatings shall be implemented with appropriate protection against exposure to elements. This protection shall still accommodate requirements of good maintenance.

1.05 SUBMITTALS

A. Refer to Sections 16000, Basic Electrical Requirements, and 17000, Basic Technical Requirements, for related requirements and additional submittals.

B. Design submittals: For each design level, include the following as a minimum:

1. Product Data: For each type of equipment. Submit performance data and descriptions or samples of all products furnished under this Section.

2. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, required clearances, method of field assembly, components, and location of each field connection. This shall include but not be limited to rack layouts and wiring diagrams, termination details, installation and
demolition drawings with final equipment placement based on the findings in the field, installation details, design drawings depicting deviations from the bid documents.

3. Product Certificates: Signed by manufacturers of equipment certifying that products furnished comply with specified requirements.

4. Installer Certificates: Signed by manufacturer certifying that installers or technicians are capable of complying with requirements.

5. Manufacturer Certificates: Signed by manufacturers certifying that they comply with requirements.

6. Design documentation depicting termination details and conduit/cabling/terminals labeling.

7. If applicable, design documentation regarding the cutover process and phases for switching from the existing PAS to the new PAS. This should also include methods to reduce Caltrain downtime.

8. Design documentation describing software and hardware configuration settings for all equipment affected by the project (including network, PA and UPS devices configs and alarm setup, etc.).

C. Submit installation drawings no later than 14 days prior to installation of PA system.

D. Testing: Submit, 30 days prior to system testing, Test Procedures and the description of the intended Test Equipment. The Test Procedures shall demonstrate how the new PA system meets each design requirement from the subpart 1.04 above.

E. Test Results: Submit, within 15 days after conclusion of system testing, a report of final Test Procedures and the Results obtained from these tests.

F. Qualifications: Submit resume showing installer qualifications.

G. Maintenance Data: For equipment to include in training and maintenance manuals specified in General Provisions. Training shall include operation, maintenance and trouble shooting of the new PA System for the Caltrain.

H. As-Built Documentation: Submit as-built documentation as specified in Section 17000, Basic Communications Technical Requirements, including all changes to approved Contract Drawings incorporated in the final installation, within 6 weeks after installation completion. The asbuilt documentation shall describe final equipment layout, installation details and the software configuration settings.

1.06 QUALITY ASSURANCE

A. Installer Qualifications: Demonstrate that the team members had previously worked on at least two successful projects of similar nature and similar hardware. Additionally, minimum three years experience installing and maintaining equipment required for this Section; and shall be an authorized representative of equipment manufacturer for both installation and maintenance of equipment required for this Section.
PART 2 – PRODUCTS

2.01 GENERAL

A. For other materials and products, refer to Section 17000, Basic Communications Equipment, Materials, and Methods, and Section 17120, Communications Wires and Cables.

2.02 EQUIPMENT

A. Unless superseded by the individual requirements stated herein, PA system electronic components shall conform to the following general requirements:

1. Solid state design
2. UL listed
3. Latest manufacturer design
4. Balanced outputs
5. EIA 19-inch rack mountable

B. Trumpet Type Loudspeakers shall conform to the following:

1. Rated for outdoor use
2. Throw: 60 feet
3. Include mounting hardware for mounting to wood/metal poles and surface/ceiling mounting.
4. Frequency Response Voice: 250-3,000 Hz
5. Frequency Response Music: 140-20,000 Hz
6. Dispersion Coverage: 120° H x 90° V
7. Speakers shall be the Atlas Sound, model APX40TN or Engineer approved equal
8. Color: Match the color of the attachment surface for wall mounted speakers, as approved by the Engineer

C. Audio Output Power Amplifiers: Power amplifiers shall conform to the following:

1. Configuration: The power amplifier shall be selected as one 2-channel amplifier per a platform. The power amplifier(s) shall be installed utilizing separate 'A' and 'B' channels. A platform shall configure 'A' and 'B' channels to alternating speakers on the same speaker poles. Amplifier input shall match the outputs of the Pre-Mixer/Pre-amplifier and accommodate its PA zone specific ambient noise compensator.
2. Frequency Response: 50 Hz to 15 kHz ± 0.3 dB
3. Output Level: Constant 70.7 volts (nominal), transformer isolated
4. Overload Protection: Output Current Limited, Thermal Overload
5. Output Power: At least 25 percent greater than the required output power (10 dB above nominal) at station nominal sound pressure levels with a minimum of 600 Watts per channel.
6. Harmonic Distortion: Maximum 0.5 percent from 30 Hz to 10 kHz
7. All indicators and controls shall be accessible from the amplifier front panel
8. Local serial access port following RS232 Data Communication specifications:
   a. Baud Rate: Selectable to 19.2K, 38.4 K, 57.6 K, or 115.2 K BAUD
   b. Data Format: Serial, binary, asynchronous; 1 start bit; 1 stop bit; 8 data bits; no parity to allow initial configuration input, configuration changes, and monitoring of system status.
9. Have an Ethernet interface module, which allows for remote control, monitoring, and generation of alarms via 100Mbs Ethernet to monitor equipment status via SNMP tools or provide equal SNMP functionality.
10. The Ethernet interface module shall be the Crown IQ-PIP-Lite or Engineer approved equal.
11. EIA 19-inch rack mountable
12. The amplifier shall be the Crown CTs1200 or Engineer approved equal.

D. Pre-Amplifier/Pre-Mixer equipment:
1. The Pre-Amplifier/Pre-Mixer shall conform to the following:
   a. Continuous adjustments from 1 second to 5 minutes for sampling of ambient noise conditions to provide a zero time delay for announcements.
   b. Automatic adjustment range: 10 to 30 dB
   c. Sense Channel: 250 Hz to 4 kHz +/- 1 dB
   d. Expand or attack and release times: 3 to 25 seconds adjustable attack time and 15 to 120 seconds release time.
   e. Support “BLU-LINK” capability to enable intercommunications with additional standalone rack-mount Pre-mixer expansion modules (BSS Audio, model BLU-BIB and/or BSS Audio, model BLU-BOB1 or approved equal) providing for expansion of Line/Mic inputs and outputs for the power amplifiers.
   f. Support reporting of abnormal/alarm conditions via the dry output contacts.
g. Provide for slots to accept:
   i. Analog Input Modules, each providing for 4 line/mic inputs
   ii. Hybrid Input Modules, each providing for 1 phone and 2 line/mic inputs

h. Provide for flexible software allowing for the following:
   i. monitoring the ambient sound level at the associated station area and automatically adjust the output level of the power amplifiers
   ii. ability to automatically adjust the output of the system to meet day time and night time noise abatement requirements of local municipalities
   iii. filter “clicking,” “pitching” and any other unsettling or undesirable sounds as specified in these specifications
   iv. elimination of positive feedback for all stationary and mobile microphones used by the new PA system (if applicable)
   v. capable of accepting flexible controls, switch and volume adjustment tools for various PA zones
   vi. capable of implementation the contract specified priority scheme for various remote and local PA announcements

i. Contain an Ethernet interface module which allows for remote control and monitoring via 100 Mbs Ethernet and TCP/IP compliant to monitor equipment status via SNMP tools over the Caltrain LAN/WAN.

j. EIA 19-inch rack mountable

k. The pre-mixer/pre-amplifier shall be the BSS Audio, model BLU-160 or Engineer approved equal.

E. Local Paging Microphone/Handsets shall conform to the following:

1. Possess the following features:
   a. Designed for Outdoor applications
   b. Physical design promotes noise canceling
   c. Rugged
   d. Push-to-talk switch
   e. Low-Impedance, Dynamic microphone

2. Frequency Response: 100 Hz to 5 kHz
3. If required, housed in outdoor, stainless steel, NEMA 4X Latching, Hinged Cover, Microphone Enclosure by Hoffman A606CHNFSS or Engineer approved equal. The assembly shall incorporate female/male XLR connector terminations allowing disconnect and removal of the microphone and its cord out of enclosure.

3. The microphone shall be a Shure 577B or Engineer approved equal.

F. Ambient Noise Sensing Microphones shall be dynamic, omni-directional, and conform to the following:
   
1. Frequency Response: 80 – 10,000 Hz
2. Low impedance, 150 ohms
3. Output Level: -61 dB
4. Weather resistant
5. Capable of being "phantom" powered (depending on the application)
6. The microphone shall be a Crown PZM11LLWRS1, a Bogen ANS500M (appropriately weather proofed), or Engineer approved equal.

G. PA cables shall:

1. Conform to the requirements Caltrain Standard Specifications 17120, Communications Wires and Cables, or Division 16, Electrical Sections.
2. The following models (or Engineer approved equals) are recommended:
   a. Speaker 4-Conductor Cable 14AWG: Belden model 6102UE for indoor installations and Belden model 5102UP for outdoor installations.
   b. Speaker 4-Conductor Cable 16AWG: Belden model 6202UE for indoor installations and Belden model 5202UP for outdoor installations.
   c. Microphone 2-pair Shielded Cable 18AWG: Belden model 6341PC for indoor installations and 5341PT for outdoor installations.

H. Protector Blocks:

1. Terminal Block Design: Protected terminal blocks shall be used for all copper cabling going to the outdoor equipment. All protector terminal blocks shall be assembled in manner, which allows for a 19 inch rack mount installation.
2. Protection Terminal Blocks: Protection shall be provided by Bourns 125-EW with Mounting Studs or Engineer approved equal.
I. AC Power Termination: Provide and install a disconnect switch assembly to terminate the incoming UPS AC power, and shall distribute power to the PA system components from this assembly.

J. Terminal Blocks:

1. Terminal block shall be provided and installed on the side panel for miscellaneous internal interconnections.

2. Brass binding posts shall be embedded in high impact polyurethane base.

3. Binding posts shall be equipped with two brass nuts and flat washers, sized to accept a minimum of two #12 AWG conductors.

K. Phone Access Device:

1. Furnish and install Telephone Line Powered Remote Access Device between the cell phone dial in line and the pre-mixer phone input. The device shall be installed in the existing telecom room and support the following features:
   a. Programmable 6 digit security code
   b. Two levels of access and programmable toll restriction
   c. Answers on the first ring. Disconnects on CPC, time out or by dialing #7
   d. Programmable 5 second to 50 minute call timer
   e. Wall mountable
   f. The Phone Access Device shall be a Viking, model RAD-1A or Engineer approved equal

L. Miscellaneous Equipment: Furnish and install the miscellaneous equipment necessary to complete the PA system. This shall include junction boxes, surface conduit between station junction boxes and PA devices, as well as miscellaneous mounting hardware and devices.

2.03 FACTORY ACCEPTANCE TESTS

A. Perform the tests based on the approved Test Procedures and Test Equipment. Demonstrate how the new PA system meets each design requirement of these specifications from the subpart 1.04 above. These tests shall include measurements of STI, coverage areas, sound pressure levels, input priorities implementation, noise filtering, feedback elimination, ambient noise sensing and automatic level control function, operation of the timed hang-up function, UPS/PA Alarm reporting, etc.

B. All equipment circuitry shall be checked for accuracy against the Contract Drawings. Tests shall verify point to point wiring and tags for proper nomenclature and terminal location.

C. All testing shall be witnessed, and, if successful, signed-off by the Contractor and the Engineer. If a test fails because of the Contractor improper execution, the Contractor shall fix and retest the failed or underperforming elements.
PART 3 – EXECUTION

3.01 INSTALLATION

A. Install equipment to comply with manufacturer’s written instructions, including taking measures to reduce noise, crosstalk, hum, and other audio quality issues.

B. If required, dismantle and remove the existing PA equipment as per design submittals (including the cutover phasing sequence) approved by the Engineer.

C. Install PA system as follows:

1. All PA equipment at the station
2. Ac power cable from station UPS power circuit breaker
3. Signal and station ground cable connection from stub-up at base of cabinet to disconnect switch assembly and ground busses
4. PA speakers and the Ambient Noise Sense microphone on the light standards and other structural members. Light standards used for speaker mounting must have an installed full-length divider to separate communication wiring from power wiring, or internal flex raceway for communication/PA wiring.
5. Conduit required to cable speakers to local PA equipment as required
6. PA cable from cabinet/rack to PA speakers, including necessary wiring and devices for noise sensing circuit(s)
7. Connections to, and termination of, all incoming telephone communications circuits from the Main Point of Entry (MPOE) cabinet
8. PA Equipment Network interfaces at Ethernet switches and PA digital I/O alarm wiring as required
9. Two Speakers in single mounting locations shall have ‘A’ and ‘B’ audio channels connected to the alternating speakers

D. Verify that all equipment is the appropriate model, properly installed and connected. The quality of the installation shall be demonstrated by tests for continuity, visual inspection and any other tests required by this Section.

E. Have all communications conduits inspected and cleaned prior to cable installation. Conduits shall have a clean, smooth concentric interior surface

F. Install PA cables in a separate conduit than those containing UTP data cable associated with other subsystems wherever possible.

G. Crossover of cables shall be avoided when cables are pulled into conduits. Care shall be taken not to have the conductors pulled tight or twisted in conduit fittings or boxes. All cables to be installed in a single conduit shall be pulled simultaneously.

H. Verify that all cables are properly routed, supported, terminated and labeled.
I. Verify that all equipment is installed in its proper location in accordance with the Engineer approved design. Verify that all mechanical connections are made and secure.

J. Wires and cables shall be continuous without splices between junction boxes, terminals, pull boxes, manholes and hand holes.

K. Provide protective covering for installed speakers and amplifiers until construction is complete. Prevent operation of amplifiers when covered.

L. Apply all IP addresses to the PA modules and Gateways as required by the Caltrain’s network standards and assigned by Caltrain Network Manager and recorded in the network Domain Name Server.

M. Configurations of the PA Mixer, Ambient Noise Compensator, and Output Amplifier shall be submitted electronically after final testing is completed.

N. Refer to Section 17060, Grounding of Communications Equipment, for grounding requirements.

3.02 FIELD QUALITY CONTROL

A. Perform the following field tests:

1. Functional tests of equipment for inputs at nominal Sound Pressure Level and STI measurements using STI-PA Female tone generators.

2. Correct phasing of all speakers

3. Noise level sensing and automatic broadcast level compensation

4. The functional tests shall fully exercise the system and determine functional compliance as follows:

a. Perform end-to-end tests for every control and indication point

b. Test all components and lines

5. Operational Test: Perform tests that include originating program and page material at microphone outlets, amplifier program inputs, and other inputs. Verify proper routing and volume levels and freedom from noise and distortion.

a. Verify full functional communication between the assigned CCF and each of the existing stations

b. Verify all features are available at each of the Control Consoles and they work as specified with the station

c. Test and record the gain using a sound level meter at each speaker location and each mid-point between speakers along the platform under normal operation. Acceptable gain levels are between 3-15 dB
6. Signal-to-Noise Ratio Test: Measure the ratio of signal-to-noise of complete system at normal gain settings, using the following procedure:
   a. Disconnect a microphone at the connector or jack closest to it and replace it in the circuit with a signal generator using a 1,000-Hz signal. Replace all other microphones at corresponding connectors with dummy loads, each equal in impedance to microphone it replaces. Measure the ratio of signal to noise.
   b. Repeat test for each separately controlled zone of loudspeakers
   c. Minimum acceptance ratio is 50 dB

7. Acoustic Coverage Test: Feed STI-PA Female tone generator into the system to measure STI levels at five locations in each zone and establish the SPL level for each zone. In addition, the SPL levels between locations in the same zone and between locations in adjacent zones must not vary more than plus or minus 3 dB.

8. Alarm testing of the speaker circuit loads: Disconnect the speakers at several points along each separate channel to insure that alarms levels are appropriately set and that alarms are sent by the equipment via the Ethernet interface and UPS Alarm Reporting.

9. Demonstrate the operation of programmed Day/Night time output level adjustment and input signal priorities.

10. Demonstrate the continued operation of the PA system during outside power outage.

11. STI Testing shall demonstrate the installed PA system outputs’ intelligibility as per the design.

12. Support Caltrain’s staff in testing announcements initiated by the CCF.

13. Retesting: Correct deficiencies, where necessary to optimize volume and uniformity of sound levels, and retest.

14. Schedule all tests with at least seven days advance notice to Engineer.

END OF SECTION
SECTION 17830
FARE COLLECTION SYSTEM

PART 1 - GENERAL

1.01 DESCRIPTION

A. Section includes requirements for the Ticket Vending Machines (TVMs) and for the Clipper Network Card Interface Devices (CIDs) as a subsystem of the station communications.

1.02 REFERENCE STANDARDS

A. Institute of Electrical and Electronics Engineers (IEEE):
   1. 802 Local and Metropolitan Area Network Standards

B. International Organization for Standard (ISO):
   1. 9001 Quality Management Standards

C. National Fire Protection Association (NFPA):
   1. 70 National Electric Code

D. Telecommunications Industry Association/Electronics Industries Alliance (TIA/EIA):
   1. 568-B Commercial Building Telecommunications Cabling Standard

E. Peripherial Component Interconnect (PCI)
   1. PCI Security Standards

F. Underwriters Laboratories, Inc. (UL):
   1. 444 Communications Cables
   2. 1863 Accessories Communications-Circuit

1.03 SYSTEM DESCRIPTION

A. The fare collection system consists of both the technical and administrative requirements for interfaces between the station Communications Equipment Room (CER), station Distribution Cabinets (DCs) and the station TVMs and CIDs. In absence of CER, some Caltrain stations may still utilize outdoor Station Communications Cabinets (SCC) also sometimes referred to as Communications Interface Cabinets (CIC). It is Caltrain's intent to phase out the SCC's/CIC's and upgrade to the CER's. Unless specifically required, in this document, for simplicity, the terms "SCC" and "CIC" are omitted; and the term "CER" is used instead as a universal substitute for these various types of station central Communications architecture.
B. Caltrain TVM Network System Description and Configuration:

1. Multiple TVM’s at each station are networked to a Caltrain TVM Virtual LAN (TVM VLAN) to consolidate data through the Distribution Cabinets (DCs) at the CER Caltrain LAN.

2. Dual Caltrain Ethernet switches’ ports at DCs and the CER shall be provisioned at 100 Mbps for a separate Caltrain TVM Virtual Local Area Network (TVM VLAN) to segregate this traffic from all others on the network. Also, the SNMP monitoring is to be established for monitoring the SNMP capable Caltrain Network devices (i.e. Switches, UPS, PA, etc.)

3. The Station TVM VLAN shall have existing connectivity to the Caltrain WAN/LAN and subsequently to a Fare Collection Data Storage Computer (DSC) located at Caltrain Headquarters in San Carlos. If the station Private Virtual Circuit (PVC) is not established, the Contractor shall assist Caltrain with enabling and programming of such PVC to enable Caltrain WAN/LAN connection. This connectivity shall allow data to be exchanged between individual Station TVMs and the Data Storage Computers. The TVM VLAN shall always be assigned to the highest priority among other station VLANs dedicated to all other remaining subsystems at the Caltrain station LAN. This shall be done to ensure other subsystems’ communications could not interfere with the passage of information between the Caltrain station Fare Collection equipment and the Caltrain DSC.

4. The station TVM shall be a direct 10/100 Mbps Ethernet connection to its assigned Caltrain network switch. For redundancy, where multiple TVMs are assigned to the Caltrain dual Ethernet Switches at the same location (DC or CER), the TVMs shall be divided into two equal groups. The first group shall be assigned to the first switch ports and the second group shall be assigned to the second redundant switch ports. If a TVM design provides for dual network connectivity, connect first TVM port to the port at the first switch and connect the second TVM port to the port at the second switch.

5. The station fiber optic backbone ring (used by TVM VLAN) shall be physically diverse using dedicated fiber optic cable and raceway. Connectivity between the TVM and its assigned distribution switch shall be made with Category 6 UTP cable.

6. In the event that the cable distance from the distribution switch is greater than 300 feet, a single-mode fiber optic cable and the corresponding media converters shall be used to provide the necessary Ethernet connectivity.

7. All TVMs and the communications equipment for the TVM operations shall utilize UPS-backed power. The UPS shall be rated to ensure TVM uninterrupted service for at least 90 min (in case of loss of station utility power).

8. TVM VLAN communications utilizes Caltrain station LAN networking devices and Caltrain station physical fiber-optic backbone. To ensure
fare collection transactions are never interrupted or lost as a result of the updates to the station infrastructure; or any activities, which may involve changes to the station LAN networking devices, racks and cabling; and Caltrain station physical fiber-optic backbone, shall be done during non-revenue hours. Prior to commencing such activities, the Contractor shall submit for approval to the Engineer the description of activities, affected equipment, cutover, testing and fallback procedures. After completion of these activities, all Caltrain station TVM’s functionality shall be verified, tested and witnessed (at the station and at the DSC headend) by the designated Caltrain personnel. See also Section 17000, Basic Communications Technical Requirements, for related and additional submittal requirements.

C. Clipper Card Interface Devices (CID) Network System Description and Configuration:

1. Clipper is a regional fare collection system that is designed and administered by the San Francisco Bay Area Metropolitan Transportation Commission (MTC). Multiple CIDs at each station are networked to a Clipper LAN (CID LAN) to consolidate data through the Distribution Cabinets (DCs) at the CER Clipper CID WAN/LAN.

2. The Clipper Contractor (working under MTC) provides for a separate Wide Area Network connection (at MPOE) between Clipper Network WAN and the station CID LAN.

3. CID Ethernet switches are separate from Caltrain dual Ethernet Switches. CID LAN is typically non-redundant and implemented as traditional star topology LAN utilizing 1Gbps fiber-optic backbone connections between the CER and DC switches.

3. CID Ethernet Switches’ ports at DCs and the CER are provisioned at 100 Mbps for a CID Local Area Network (CID LAN).

4. Even though CID LAN network devices share Caltrain station physical fiber backbone cabling (and fiber-optic and CAT6 patch panel equipment), CID station LAN and Caltrain LAN network devices are physically segregated to avoid any type of communications interface between these two LANs.

5. The CID LAN Network devices are furnished and programmed by the Clipper Contractor. This includes CID Router, CER CID Ethernet Switch, DC CID Ethernet Switches and actual CID card readers to be installed at the CID poles.

6. Caltrain furnishes CID poles and CID poles temporary covers. The Clipper Contractor is responsible for their installation.

7. The Clipper Contractor is also responsible for provision and installation of all remaining station equipment serving CID equipment, such as: rack space; junction boxes, all interconnecting conduits and comm/power wiring; and provision, installation and termination of all necessary 24VDC
power supplies in DC cabinets (one power supply per two CID devices), etc.

8. Clipper Card Interface Devices (CIDs) are typically installed near the station TVM shelters.

9. The CIDs are powered by 24VDC power from the station Distribution Cabinets. The corresponding 24VDC Power Supplies shall be powered by the UPS-backed power. The UPS shall be rated to ensure TVM uninterrupted service for at least 90 min (in case of loss of station utility power).

10. The CIDs communications cabling shall be Cat 6 cables or Single-Mode fiber cables from the associated CID Ethernet switch. The CID communications and power cables shall be routed within the same Communications conduits.

11. Clipper LAN communications utilizes Caltrain station LAN networking patch-panel equipment, racks and Caltrain station physical fiber-optic backbone. To ensure CID transactions are never interrupted or lost as a result of the updates to the station infrastructure; or any activities, which may involve changes to the mentioned above station LAN equipment, shall be done during non-revenue hours. Prior to commencing such activities, the Clipper Contractor shall submit to the Engineer for approval the description of activities, affected equipment, cutover, testing and fallback procedures. After completion of these activities, all Caltrain station CID’s functionality shall be verified, tested and witnessed (at the station and at the Clipper headend) by Caltrain and Clipper personnel. See also Section 17000, Basic Communications Technical Requirements, for related and additional submittal requirements.

1.04 SUBMITTALS

A. Refer to Section 17000, Basic Communications Technical Requirements, for related and additional submittal requirements.

B. Preliminary Design Technical (PDT) Requirements:

1. Complete product data including description and model number, shop drawings, catalog cuts and technical literature for the following equipment and material:

   a. Data switch

   b. Fiber and copper interconnection equipment

   c. Media conversion equipment (if applicable)

   d. Cable

2. Fare Collection (TVM and CID) LANs logic diagram and overall system description.
3. Interface description between the TVM VLAN and other Communications subsystems required to complete the transfer of Caltrain Fare Collection data from TVMs to DSC.

4. Proposed Ethernet switch operating software with descriptive documentation, including, but not limited to:
   a. Release Notes
   b. Product Bulletins
   c. Applicable Field Notices
   d. Design Guides

5. Equipment operating instructions or details

6. Mounting and installation details, rack layouts

7. Complete End-to-End wiring diagrams

8. Inside Plant (ISP) and Outside Plant (OSP) cable routing, pair, and fiber strand usage diagrams

9. Intra and Inter rack wiring

10. Patches

11. Power and grounding

C. Final Design Technical (FDT) Requirements: Include the following information as part of the Final Design submittal package for the Fare Collection equipment:

1. Updated PDR information. All drawings, calculations and design information shall reflect a final design.

2. Fiber optic link loss budgets for all fiber optic spans between the CER and the Fare Collection network devices sufficient to show that all proposed spans meet published link loss budgets.

D. Installation Work Plans: Submit the following installation document for each site prior to the scheduled installation activities. The Installation Work plan shall include:

1. Drawings showing plan and elevation details of equipment including conduit interface

2. Cable and wire requirements

3. Grounding details

E. Calculations or Certifications: Submit fiber span loss calculations (as required in the Design Review Sections) to validate switch distances.
F. Product Samples: Submit and demonstrate product samples when requested by the Engineer.

G. Cutover Plan and Test Plan and Procedures. To ensure Fare Collection transactions are never interrupted or lost as a result of the testing, cutover or installations; any activities, which may potentially affect the station TVM VLAN / CID LAN and/or related equipment, shall be done during non-revenue hours.

1. Test Program Plan: Include all the required information for the Fare Collection equipment in the Test Program Plan as outlined in these Specifications including routing, network paths, device and software functions (i.e. programmable alarm and SNMP settings), which shall include testing equipment required; any Caltrain, Clipper and/or Contractor personnel required (including their locations); tested functions, test sequence and pass/fail criteria. All elements/functions, which failed as a result of Contractor’s errors shall be corrected.

2. Factory and Inspection Test Procedure: Submit a complete factory test and inspection procedure to satisfy all the requirements outlined under “Source Quality Control” in this Section.

3. Field Test Procedure: Submit a complete field test procedure to satisfy all the requirements outlined under “Testing and Inspection” in this Section.

4. Cutover Test Plan: Submit for approval to the Engineer the description of activities, all affected subsystems and equipment, cutover sequence, successful cutover variation criteria and fallback plan/procedures.

5. End-to-End Acceptance Test: End-to-End Test shall be performed for all communication wiring between CID Router and all CID Switches; all power and communication wiring (including fiber, if applicable) between CID switches in DCs and CID poles at station.

6. System Integration Test (SIT): Provide qualified personnel to support the Fare Collection integration test as described under “Testing” in this Section. The Engineer will direct the SIT.

H. Test Records: Submit the Test Records for review one week after the completion of each test in accordance with these Specifications.

I. Manufacturer Qualifications: Submit qualifications for any manufacturer differing from those specified herein and obtain Engineer’s prequalification and approval. Acceptability of the manufacturer shall be based on the manufacturer’s experience, qualifications, certifications (i.e. ISO-9001), equipment reliability, compliance with standards specified herein, and full compatibility with Caltrain’s existing systems.

J. As-Built Documentation: Submit complete As-Built documentation and drawings, as specified in Section 17000, Basic Communications Technical Requirements, and the following requirements.

1. Include complete equipment data with operating instructions.
2. Accompanying each interface drawings package shall be a written interface specification that details the functional, electrical and mechanical interface properties.

3. Default or As-built Configuration and Provisioning Information for each programmable piece of equipment to allow system integration by follow-on contractors and consultants, including:
   a. Programming passwords
   b. Programmable feature settings
   c. Board level switch/strap settings
   d. Node addressing information
   e. Programmable alarm and SNMP settings

4. Card layout or slot configurations (component equipment inventory).

5. Any other configuration or provisioning which deviates from manufacturer’s default state.

1.05 QUALITY ASSURANCE

A. Applicable Standards and Codes: Design, fabrication, inspection, installation and testing shall comply with all applicable Standards and Codes as listed herein. All equipment and methods shall comply with the standards listed under Reference Standards herein.

B. Material and Workmanship Requirements:
   1. All equipment provided under this Section shall be UL listed.
   2. All products specified herein shall be subject to the Engineer’s approval based on the Contractor’s ability to demonstrate adherence to these Specifications and Engineer’s approval of the manufacturer’s quality process.
   3. All products shall be compatible with existing WAN and DSC elements in order to perform the intended use set forth by the Engineer. WAN and DSC elements are networking components to connect the station to the CCF or other remote monitoring and control locations.
   4. Use no discontinued or end-of-life product models, refurbished equipment, or products scheduled for end-of-life, end-of-sale, or end-of-service within one calendar year of the installation date.

PART 2 - PRODUCTS

2.01 FARE COLLECTION MATERIALS AND EQUIPMENT

A. Owner-furnished materials and equipment: Ticket Vending Machines (TVMs), TVM pedestals, Card Interface Device (CID) Poles and Poles’ temporary covers.
B. Clipper Contractor furnishes, installs and performs the required programming the WAN/LAN Connection, CID Router, CER CID Ethernet Switch, DC's CID Ethernet Switches and actual CID card readers (to be installed at the CID poles). TVM and CID equipment quantities vary with each project (see the Contract documents for the specific project quantities).

C. Install TVM Pedestals, CID poles and CID poles temporary covers and the associated grounding equipment.

D. Provide and install of all remaining station equipment serving station TVM and CID equipment, such as: rack space; all interconnecting conduits and comm/power/grounding wiring (power conductors, Category 6 or fiber optic cable as indicated on the Contract Drawings); and provision, installation and termination of all necessary CID 24VDC power supplies in DC cabinets (one power supply per two CID devices), etc.

E. Provide TVM LAN field fiber-to-copper media converter/switch (if applicable).

F. Provide Caltrain switch and TVM IP address, subnet, and default gateway. Establish highest priority for TVM VLAN. Assist Clipper Contractor personnel with programming and testing of CID network devices.


H. Provide, install, and test all TVM Fare Collection software applications from the Caltrain’s Headquarters Fare Collection Network.

2.02 CALTRAIN DATA SWITCH

A. All network equipment shall come with the latest secure IOS image supporting SSH, cryptomap, etc.

B. All network equipment shall be PCI compliant.

C. TVM VLAN shall utilize TCP/IP as the transport and network layer service protocol. Physical Ethernet interface settings shall be set to 100 Mbps, Full Duplex.

D. TVM VLAN shall utilize the Caltrain dual redundant Ethernet switches placed within CER and DCs as shown in the Contract documents.

E. CID LAN shall utilize the Clipper Router and Ethernet switches placed within CER and DCs as shown in the Contract documents.

2.03 SOURCE QUALITY CONTROL – FACTORY TESTING AND INSPECTION

A. Notify the Engineer in writing at least 10 days prior to each scheduled test.

B. Conduct Factory Testing on individual equipment or assembled subsystems after all mounting, installation, wiring and other activities to support turn-up are complete.
C. Perform diagnostic testing for all equipment and all communications ports.

D. Perform functional testing and validation of equipment settings on all equipment.

E. Any commercial off-the-shelf equipment that shares a common interface shall be assembled, integrated, and factory tested for compatibility.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Equipment shall be installed as shown in the Contract Drawings, and in accordance with the manufacturer’s recommendations.

B. Install data transmission equipment, media conversion (if applicable), and interconnection equipment at the CER or DC to each TVM or CID per the Contract Drawings. Install 24VDC power wiring for the CID's per the Contract Drawings.

C. Coordinate closely all Work described in this Section with the Engineer of the Fare Collection Vendor.

D. Coordinate details of all interface requirements with the Engineer and be responsible for End-to-End testing.

E. Coordinate all civil Work and installation of all facilities, equipment and cables with the Engineer.

F. Cables and Wiring:

1. Provide copper or fiber optic cable from each TVM and CID routing through assigned conduits to networking equipment located in the CER or Distribution Cabinets per the Contract Drawings. Terminate and test all fiber optic strands or copper pairs (including 24VDC power wiring for CID's), whether assigned working or spare (dark).

2. Provide a Fiber Distribution Panel (FDP), Fiber Slack Enclosures, fiber patch cords, SC-type connectors; splice trays, and other components for a complete structured cable system in accordance with these Specifications.

3. Provide proper Category 6 UTP cable termination hardware and circuit protection in accordance with these Specifications.

4. Install UPS electrical power from assigned UPS distribution panels to each TVM and CID Power Supplies per the Contract Drawings. Ensure proper grounding and lightning/surge protection for all TVM and CID equipment installations.

5. Prior to TVM or CID installation, seal and protect exposed ends of power and signal cables, and coil at least 12 feet of service length in the TVM junction box or pull-box for future termination or at the top of the CID Pole and the Pole Temporary Cover.
G. TVM and CID equipment quantities and locations shall be in accordance with the Contract Drawings.

3.02 TESTING AND INSPECTION

A. Perform the following inspection and test on the Fare Collection equipment at each installed location. Notify the Engineer in writing at least 10 days prior to each scheduled test. Any testing, which may potentially disrupt or hinder the performance of the operational Fare Collection equipment shall be performed during non-revenue hours.

B. Factory Test and Inspection: See Source Quality Control herein.

C. Field Inspection: Field inspection of the Fare Collection equipment shall verify the following:
   1. Equipment damage in transit
   2. Equipment, port, and cable labeling
   3. Power supply integration and mounting
   4. Cable routing
   5. Unobstructed air flow to vented equipment

D. Field Test: The following tests shall be performed in the presence of the Engineer:
   1. Functional testing from each TVM to the Data Switch interface. If required, utilize a data test set at the demarcation point to validate connection, TVM VLAN priority and data transfer from each TVM.
   2. Failover testing (for TVM equipped with local switching and ring protection): Disconnect one side of dual port field media converter/switch and ensure TVM maintains networking. Restore connections and remove opposite path fiber ports and repeat testing.
   3. Verify power connections and grounding for proper gauges, continuity, ground resistance/faults, acceptable voltage levels, cross-talk, etc., test and record the results.
   4. Test all fiber or copper distribution cabling per TIA/EIA 568-B standards.

E. End-to-End Acceptance Test: Test all communication, power and grounding wiring for station CID equipment.

F. Cutover Testing: Cutover activities shall be performed during non-revenue hours only. If failed, the Cutover shall be repeated only when the problem(s) is discovered and fixed.
   1. Data Cable tests: Prior to cutover testing, all data cable shall first be tested. The test results shall be submitted 2 weeks prior to cutover date
to the Engineer for review and approval. Do not begin cutover without the Engineer’s approval of the data cable test results.

2. Ensure all functional testing for each TVM was successful.

3. Disconnect the existing station Caltrain WAN/LAN Router from the leased line and connect the CER dual switches to the new station Caltrain WAN/LAN router and communications equipment.

4. Conduct System Integration Test (see below) and verify the updated communications for the involved devices (including Caltrain TVM’s)

G. System Integration Test: Provide sufficient technical staff to support the following testing activities during the Owner’s systems integration test.

1. Full path Ethernet connectivity testing between TVMs and Fare Collection DSC.

2. Functional end-to-end testing between Fare Collection DSC and each networked TVM.

3. TVM intrusion alarm operation and reporting.

4. Assist Clipper Contractor personnel with the CID equipment testing and troubleshooting.

5. Conduct TVM and CID testing in the event of updates to the station infrastructure or any other activities, which involve changes to the station networking equipment, which may potentially affect performance of the TVM or CID equipment.

END OF SECTION
SECTION 17850
CLOSED CIRCUIT TELEVISION CAMERA (CCTV) SYSTEM

PART 1 - GENERAL

1.01 DESCRIPTION

A. Section includes requirements for the Closed Circuit Television Camera (CCTV) System and associated Local Area Network (LAN) as a subsystem of Caltrain station communications. These requirements are for standard Caltrain station video surveillance applications. For other applications (i.e., maintenance facilities, tunnels, bridges, infrared/wireless CCTV, etc.) refer to the corresponding project additional specific requirements.

B. Coordinate and provide interfaces between the station Communications Equipment Room (CER) and the station CCTV subsystem. Note that, in absence of CER, some Caltrain stations may still utilize outdoor Station Communications Cabinets (SCC) also sometimes referred to as Communications Interface Cabinets (CIC). In the future, SCC's/CIC's will be phased out and upgraded to CER's. In these specifications, for simplicity, the terms “SCC” and “CIC” are omitted. The term “CER” is used instead and it covers all types of station central Communications equipment implementation.

C. The design (from concept to final stage), installation and acceptance shall follow CPTED (Crime Prevention Through Environmental Design) guidelines. The design, installation, testing and acceptance shall be approved and witnessed by CPTED certified personnel and Caltrain.

1.02 REFERENCED STANDARDS

A. Electronic Industries Association (EIA):
   1. Standards 170, 232, 250C and 485

B. Federal Communications Commission (FCC):

C. International Standards Organization (ISO):
   1. 9001 Quality Management Systems - Requirements

D. Military Standards (MIL-STD)
   1. 454 Standard General Requirements for Electronic Equipment
   2. 810E Method 509 Procedure 1 – exterior salt atmospheres

E. National Fire Protection Association (NFPA):
   1. 70 National Electric Code (NEC)
1.03 SYSTEM DESCRIPTION AND CONFIGURATION

A. Closed Circuit Television Cameras (CCTVs) at each passenger station shall be connected into the Station LAN to consolidate data at the Communications Equipment Room (CER) via a 100/1000 Mbps multi-port redundant Ethernet Station LAN switches.

B. Redundant Ethernet switch ports at the CER are provisioned at least 100 Mbps for a separate CCTV Virtual Local Area Network (VLAN) to segregate the CCTV traffic from all others on the network.

C. The station CCTV VLAN shall share the station LAN 1000 Mbps Ethernet backbone bandwidth with other station subsystems. The station LAN 1000 Mbps backbone will operate in a physical ring topology via the station single-mode fiber optic cable.

D. Depending on the cabling distance, each station CCTV location shall be directly connected to its assigned network switch using dedicated either copper (Category 6) or fiber optic cable and raceway.

E. CCTV cameras requiring Power over Ethernet (PoE) shall utilize Cat 6 cable. The Distribution Cabinet redundant Ethernet Switches shall either incorporate PoE capable Ethernet ports or utilize external PoE power injectors. The external power injectors shall be used only for locations where the Ethernet switches are existing and do not incorporate PoE capable ports functionality.

F. At field locations where the VMS (visual message sign system) occupy the same pole as the CCTV, separate raceway will be used for each subsystem.

G. CCTV cameras connections shall be equally distributed between two redundant switches/rings. When available, CCTV cameras with integrated network switching and route protection capabilities shall be provided dual copper or fiber cable connectivity for maximum network redundancy.

H. All station cameras will use TCP/IP protocol. Digital video recorders, mobile computer, and motion detection software will be housed in the station CER.

I. Products specified herein will cover digital (IP) cameras. The design preference of choice for new construction is an IP video camera to reduce cabling, electronic components, and power consumption. Whenever cabling distances allow, IP cameras shall operate Power-over-Ethernet (PoE) IEEE 802.3af.

J. The station CCTV system components shall be compatible with the Caltrain existing CCTV headend in Caltrain headquarters in San Carlos provided by Verint Nextiva. The modifications to the existing Caltrain headend will be performed by Caltrain. The Contractor shall facilitate integration of the new station CCTV equipment into the existing CCTV headend and coordinate with Caltrain on the
design, implementation and testing details of the new equipment affecting the existing system.

1.04 DETAILED WORK SCOPE

A. This work includes installing field CCTV assemblies consisting of camera, zoom lens, pan/tilt drive, power supply and standard or dome enclosure. Work scope includes furnishing and installation of CCTV assembly, cabling, network electronics, and CCTV interface panel and the station Digital Video Recorder (DVR). The work also includes furnishing and installing communication interface for fiber optic and data cable. Camera assembly shall include all necessary for proper operations pole or surface mounting and attachment hardware and electrical cabling and connections.

B. The CCTV camera system shall include, but not be limited to, the following components and features:

1. CCTV camera with auto focus zoom lens at a mounting height above the platform or station surface as detailed in the Contract drawings.

2. The CCTV Camera assembly and/or mounting hardware shall allow for the specified pan and tilt.

3. Standard or dome, watertight environmental housing, and, if required by design, capable of being pressurized.

4. Mounting hardware with no exposed camera control or power wiring.

5. CCTV camera pole with or without the use of a lowering device, with a pole height above the platform surface as detailed in the site specific drawings (stand-alone CCTV camera poles are typically used only if the existing station structures cannot be utilized).

6. Site data/power cabling for IP cameras.

7. Camera control electronics and equipment (i.e., hardware and software).

8. CCTV assembly with azimuth and labeling capabilities.

9. Power, and data/video cables for external power supplies (if required), images, and camera controls.

10. Transient voltage suppression and surge/lightning protection.

11. Network communication cables.

12. Power over Ethernet injectors as required by the camera locations and design.

13. Indication of the blank out or privacy zone positions using text messages on the video display.

15. Video processing, storage and display equipment.

16. Any and all ancillary equipment required for a fully operational, shared surveillance system.

17. NTCIP compatible driver.

18. 4-wire 422 interface, if applicable.

19. Text labeling on video display.

1.05 SUBMITTALS

A. Refer to Section 17000, Basic Communications Technical Requirements, for related and additional submittal requirements.

B. Submit detailed catalog data for all equipment and materials, including accessories.

C. If proposed CCTV mounting is not an off-the-shelf item or was not originally designed to be used for the proposed mounting arrangement, submit structural design, including drawings and calculations, signed and sealed by a Structural Engineer licensed in the state of California.

D. With each Design Review level, submit the updated CCTV coverage map. The CCTV coverage map shall identify for each camera: camera type and model; mounting elevation; tilt; direction of coverage, radius of coverage; horizontal and, where necessary, vertical angles of view. Coordinate with Caltrain the desired level of detail (pixel per foot) requirements for each camera. Typical high priority targets require camera resolution of more than 40 pixels per foot (forensic level of details); the remaining areas typically require at least 20 pixels per foot (general level of details).

E. With each Design Review level, submit the proposed WAN/LAN/VLAN IP addressing scheme and security scheme for all new CCTV elements to match the addressing scheme and security scheme of the existing Caltrain CCTV headend.

F. Submit installation drawings no later than 14 days prior to installation of the CCTV system. Include description of modifications and the cutover sequence for incorporating of the new CCTV equipment into the existing Caltrain CCTV system and fall-back procedures (in case something goes wrong). Proceed with the installation only after the Engineer approval of installation submittal.

G. Testing: Conduct local station CCTV testing to verify each camera’s settings and coverage details as per the approved Design Submittals. After the successful local testing and the cutover to the existing CCTV headend, assist Caltrain personnel with integrated headend/field CCTV system testing. All tests shall be done as per the approved test procedures and witnessed/signed-off by the Contractor and Caltrain. Prior to signing off a tested equipment/function; if found, each issue in the Contractor’s scope of work shall be corrected by the
Contractor and retested prior to final acceptance by Caltrain. Submit, within 15 days after conclusion of system testing, a report of final Test Procedures and the Results obtained from these tests.

H. As-Built Documentation: Submit complete As-Built documentation and drawings, as specified in Section 17000, Basic Communications Technical Requirements, for equipment. Also, the As-Built documentation shall contain the asbuilt CCTV System coverage areas, the station CCTV equipment final LAN/WAN and Software configuration settings.

I. Operation and Maintenance Data: Provide documentation containing complete details of the delivered equipment including operating and maintenance procedures and manuals.

PART 2 - PRODUCTS

2.01 GENERAL

A. Typical Station CCTV System Components:

1. Integrated camera assembly: Depending on each camera type, it may include following elements: camera, lens, housing, pan-tilt drive unit, infrared illuminator, fan/heater/blower, fiber transceiver, power supply, mounting brackets and other mounting hardware.

Some CCTV Camera manufacturers provide for complete “all-in-one” camera assemblies, where all elements are already included and match (do not require separate design and manual labor for the assembly) and include all necessary equipment for mounting and termination. These types of CCTV assemblies provide significant saving for the project by simplifying the design and reducing the amount of labor.

CCTV camera assemblies are typically made specifically for either outdoors or indoor applications. Some vendors, however, produce universal types of camera assemblies, which may be used for either environment.

2. An integrated camera assembly is connected (via the associated conduits) to the closest point of service, which is typically the closest redundant Ethernet switch located at either the nearby Distribution Cabinet (DC) or Communication Equipment Room (CER). Typically PoE is used for powering the camera assemblies.

For remote locations, a fiber optic cabling is used, which requires the camera assembly to incorporate a fiber transceiver and for the designers to identify local sources of power. Where installation of the fiber cabling is problematic, a wireless link maybe considered for the remote sites. Implementation of the wireless links; however, is not recommended (due to numerous challenges of the transit environment) and shall be considered as a last option resort.

3. A rack-mounted Station CCTV DVR equipment with all necessary hardware and software configured to communicate with the Caltrain
existing headend. The station DVR equipment shall be mounted into either the dedicated rack within CER; or dedicated standalone rack in telecommunication closet.

4. All other materials necessary for installation of the CCTV and other cabinets and camera assembly (including materials required to interface the CCTV camera assembly to the electrical power) as required.

2.02 INTEGRATED IP FIXED CAMERA ASSEMBLY

A. Product Description:

1. The specified product shall be a high-resolution Day/Night network camera integrated into an all-weather NEMA 4/IP66 rated enclosure designed for both indoor and outdoor applications. The integrated camera is an industrial grade, color, and full-featured, day/night 5.0 megapixel network camera.

The unit consists of 1) a camera and lens module, 2) a wall, ceiling, and parapet arm, and 3) a power/data back box. The camera shall be powered via the Ethernet (Power-Over-Ethernet) using an IEEE 802.3af power source or may be powered directly via 12-24VDC or 24VAC.

The product shall be designed to meet or exceed industrial and surveillance applications requiring a low power, rugged video camera with IP network capability. The camera shall have a built-in web server and FTP server.

B. General Product Requirements:

1. The specified product shall be a high-resolution, Day/Night ½-inch optical format, network camera integrated into an all-weather NEMA 4/ IP66 rated enclosure designed for both indoor and outdoor applications.

2. The operating temperature range shall be -22 deg F to +122 deg F.

3. The integrated camera shall be an industrial grade, color, and full-featured, Day/Night 5.0 megapixel network camera with ½-inch optical format.

4. The camera shall be powered via the Ethernet (Power-Over-Ethernet) using an IEEE 802.3af power source or powered directly via 12-24VDC or 24VAC.

5. The power/data back box shall allow entry of cables from the rear of the box that pass through two ½-inch Heyco watertight fittings. A ½-inch NPT mount shall also be available at the bottom of the box to accommodate cables or conduit.

6. The back box shall be supplied with arm hangers to hold the camera/arm module in place on the back box during wall, ceiling, or parapet mounting installation.
7. The back box shall provide both input and output alarm trigger connections.

8. The camera unit shall have a pivoting arm to allow the product to be wall, ceiling, or parapet mounted without requiring any additional hardware.

9. The camera housing shall be 360 deg adjustable in the pan direction and 180 deg in the tilt direction.

10. The camera shall be vandal and tamper-resistant.

11. The product shall be available with any of the following lenses:
   a. 4-12 mm, f1.4, 1/2-inch CS format, wide varifocal IR corrected lens
   b. 12-40 mm f1.4, 1/2-inch CS format, telephoto varifocal IR corrected lens
   c. 1.8-3 mm, f1.8, 1/2-inch CS format, ultra wide varifocal IR corrected lens

12. To simplify lens setup during installation, an analog output for a display monitor shall be accessible when the lens housing is separated from the camera housing.

13. A mechanical reset button shall be available in the back box to return the camera to the factory default setup.

C. Camera Specifications:

1. The Day/Night high-resolution color camera specified shall incorporate a progressive scan CMOS imager with a 1/2-inch optical format, not less than 5.0 million megapixels and shall have a dichroic infrared mirror.

2. The image resolution shall be minimum 2560(H) x 1920(V) pixels. The camera’s aspect ratio (horizontal vs. vertical lines) shall be user configurable and not limited to only 4:3 or 9:6 aspect ratios.

3. The camera shall produce 10 frames per second (fps) at full 2560(H) x 1920(V) resolution. The maximum frame rates are 10fps at 4:3 aspect ratio and 13fps at 16:9 aspect ratio.

4. Minimum light requirement to produce a color image shall be approximately 0.30 lux (0.03 fc) with a f1.2 lens. When in the IR sensitive Night mode, less than 0.05 lux (.005 fc) will produce a black and white image.

5. The camera shall provide automatic white balance, automatic exposure, gain control, electronic shutter, and backlight compensation. It shall use MJPEG (and MPEG-4/H.264, if available) video-compression. The images can be viewed via a standard browser.
6. A night mode feature, shall slow the shutter speed down to enhance the nighttime sensitivity of the camera.

7. The camera shall have on-camera storage. Provide for a minimum 32GB card for on-camera storage purposes.

8. Digital image authentication shall be optionally available and licensed to verify that images have not been altered, manipulated, or tampered with, in any way.

9. The camera shall provide on-screen time/date and text displays. The text display can be programmed to dynamically change when motion alarms are detected.

10. The camera shall provide built-in motion detection allowing up to eight separate, rectangular motion windows (zones) to be independently configured. Each window may have its interior pixels included or excluded from consideration by the motion detection algorithm. Windows configured to have pixels included in the motion calculations shall allow the threshold of both the sensitivity (pixel values) and size (quantity of pixels) to be set.

11. The camera shall provide on-screen, digital, pan/tilt/zoom on live or recorded video.

12. Provide User and Administrator password protection levels.

13. Up to eight (8) rectangular privacy windows may be configured to mask out specific video from view in the image.

14. The camera shall capture image sequences by time lapse intervals or trigger events and transfer the jpeg images via FTP and/or e-mail.

15. Specialized software that enables multiple users to receive alerts via a pop-up window when the camera receives an internal or external trigger shall be available via an optional license upgrade.

D. Camera Networking Requirements:


2. Camera functionality shall be available to users running versions of Java VM and web-browser applications released after January 1, 2004.

3. The camera shall provide integrated support for IP, TCP, UDP, ICMP, ARP, FTP, SMTP, DHCP, HTTP, RARP, BOOTP, SNMP, Telnet, and TFTP protocols.

4. The camera shall provide a multiview function where a single browser page shall be capable of displaying streaming images from up to nine cameras simultaneously.
5. No unique or proprietary client software shall be required for viewing or controlling the camera.

6. The camera shall be user configurable and the administrator may functionally or aesthetically modify the camera’s web pages.

7. The camera shall provide for up to 64 area-of-interest streams that can be independently created of any size and aspect ratio and with any desired display resolution. Substream frame rate can also be configured, up to the maximum frame rate delivered by the camera.

8. The camera shall offer a web interface for quick creation of up to three substream windows with auto-port configuration of each stream.

E. Camera Recording/Playback Requirements:

1. The manufacturer shall offer optional, licensable embedded recording/playback software that allows images to be recorded to an external FTP server.

2. Images may be stored at a fixed periodic record rate and/or when triggered by motion and/or external input. Playback shall allow all images recorded to be viewed forward or backward in time.

3. The camera shall record all images in a proprietary file format.

4. The camera shall include pre-event and post-event recording, time-date search, JPEG snapshot, and AVI export functionality.

F. Event (Alarm) Handling Capability:

1. The camera shall be capable of recording an event as pre and post event images. The camera shall also be able to transfer the event’s JPEG images to an FTP server via File Transfer Protocol (FTP). Events may be triggered using camera motion detection or from an external device input such as a relay.

2. When triggered from an external input or the camera’s motion detector, the camera shall be capable of sending JPEG images via e-mail and/or sequences of images to an FTP server.

3. A relay output shall be available upon the activation of the camera’s motion detector or external relay input. The relay output may also be manually activated from the live view screen.

G. Back box Connections:

1. RJ-45 Ethernet connector (IEEE 802.3af PoE compliant)

2. Punch Down terminal for CAT5, CAT5e, or CAT6 cable
3. Screw terminal: Direct power for 12-24VDC or 24VAC, Trigger In and Trigger Out

H. Electrical Specifications:
1. Power Consumption: 6 watts maximum
2. Power requirement: 12-24VDC or 24VAC or via IEEE 802.3af Power-over-Ethernet on CAT5, CAT5e, or CAT6 cable

I. Mechanical Specifications:
1. Weight (without lens): 96oz (2839g)
2. Dimensions: 15.36 L x 5.18 W x 9.58 H inches
3. Lens: As required by the application
4. The camera shall feature solid-state components to resist shock and vibration and have no moving parts

J. Environmental Specifications:
1. Temperature range: -22 deg. F to +122 deg. F
2. Environmental Enclosure rating: IP66/NEMA 4

K. Certifications and Approvals:
1. Electromagnetic Compatibility
   a. Emissions:
      i. FCC, Class A part 15
      iv. AS/NZS CISPR 22:2002; Class A
   b. Immunity:

2. Safety:
   a. EN 60950-1:2001 with A11:2004
   b. IEC 60950-1:2001
3. Restriction of Hazardous Substance (RoHS): All material and/or components used in the manufacture of the product shall be in compliance with the EU Directive 2002/95/EC RoHS.

L. IP camera assembly shall be IQinVision model IQeye Sentinel Series, IQeye855v7 or Caltrain approved equal.

2.03 INTEGRATED DOME IP CAMERA ASSEMBLY

A. Product Description:

1. The product specified shall be an all-in-one vandal/tamper resistant 5.0 megapixel resolution color dome camera designed for indoor/outdoor applications providing multiple H.264 (MPEG4, Part 10) and simultaneous MJPEG streams that can be individually configured. The dome camera shall provide 10fps at maximum resolution with audio, and shall conform to the ONVIF and PSIA standards.

2. The camera shall provide for Day/Night functionality with high sensitivity for use in low light indoor/outdoor applications, and is prepackaged with a varifocal IR corrected lens to allow manual zoom and focus adjustment.

3. The dome camera shall be constructed of cast-aluminum housing with polycarbonate dome bubble and auto tracking inner liner. The dome camera shall be designed to protect against water and dust to IP66 / NEMA 4 standards; require low power the dome camera such as PoE (IEEE 802.3af) compliant, or direct power by 12-24VDC or 24VAC.

B. General Product Requirements:

1. The specified product shall be a high-resolution, Day/Night ½-inch optical format, network camera integrated into an all-weather NEMA 4 / IP66 rated enclosure designed for both indoor and outdoor applications.

2. The operating temperature range shall be -22 deg F to +122 deg F.

3. The integrated camera shall be an industrial grade, color, and full-featured, Day/Night 5.0 megapixel network camera with ½-inch optical format.

4. The camera shall be powered via the Ethernet (Power-Over-Ethernet) using an IEEE 802.3af power source or, if necessary, powered directly via 12-24VDC or 24VAC.

5. The power/data back box shall allow entry of cables from the bottom of the dome that pass through watertight fittings.

6. Various types of mount shall also be available to accommodate various types of mounting surfaces (i.e. wall, ceiling, or parapet) and/or mounting installations.
7. The assembly shall provide both input and output alarm trigger connections.

8. The IP dome camera shall have a 3-axis gimbal providing 360° pan, 90° tilt and 350° azimuth for easy camera positioning.

9. The camera shall provide for audio input/output: Microphone/Line In and Line Out

10. The camera shall be vandal and tamper-resistant.

11. The product shall be available with any of the following lenses: An integrated 3-13mm megapixel IR corrected varifocal lens with F1.4, and 1 / 2.5” optical format.

12. To simplify lens setup during installation, an analog output for a display monitor shall be accessible when the lens housing is separated from the camera housing. TCP/IP protocol video output via a RJ-45 Ethernet connection and an NTSC (PAL) analog video output via a BNC connection outputs may be used simultaneously.

13. A mechanical reset button shall be available to return the camera to the factory default setup.

14. The IP dome camera shall conform to the ONVIF and to the PSIA standards.

C. Camera Specifications:

1. The Day/Night high-resolution color camera specified shall incorporate a progressive scan CMOS imager with a 1/2-inch optical format, not less than 5.0 million pixels and shall have a dichroic infrared mirror.

2. The image resolution shall be minimum 2560(H) x 1920(V) pixels. The camera’s aspect ratio (horizontal vs. vertical lines) shall be user configurable and not limited to only 4:3 or 9:6 aspect ratios. The camera shall produce 10 frames per second (fps) at full 2560(H) x 1920(V) resolution and at either 4:3 aspect or 16:9 aspect ratios.

3. The IP Dome camera shall have three video streams that can be individually configured for H.264 and MJPEG from the webpage and API interface. The IP dome camera shall have three video streams that can be independently configured for different resolutions. The IP dome camera shall have quality control over the MJPEG image stream with four selectable quality values from the webpage interface and with 86 selectable compression values from the API interface.

4. Minimum light requirement to produce a color image shall be approximately 0.30 lux (0.03 fc) with a f1.2 lens. When in the IR sensitive Night mode, less than 0.05 lux (.005 fc) will produce a black and white image. The IP dome camera shall provide an automated IR filter that will automatically switch from color to monochrome enhancing low lighting or in applications where IR illumination is utilized.
5. The camera shall provide automatic white balance, automatic exposure, gain control, electronic shutter, and backlight compensation. Dome camera dynamic range shall be 71dB. It shall use H.264 and MJPEG video-compression. The images can be viewed via a standard browser.

6. A night mode feature shall slow the shutter speed down to enhance the nighttime sensitivity of the camera.

7. The camera shall have on-camera storage using Micro SD Class 6+. The Contractor shall provide a minimum 32GB card for on-camera storage purposes.

8. Digital image authentication shall be optionally available and licensed to verify that images have not been altered, manipulated, or tampered with, in any way.

9. The camera shall provide on-screen time/date and text displays. The text display can be programmed to dynamically change when motion alarms are detected.

10. The camera shall provide built-in motion detection allowing up to eight separate, rectangular motion windows (zones) to be independently configured. Each window may have its interior pixels included or excluded from consideration by the motion detection algorithm. Windows configured to have pixels included in the motion calculations shall allow the threshold of both the sensitivity (pixel values) and size (quantity of pixels) to be set.

11. The camera shall provide on-screen, digital, pan/tilt/zoom on live or recorded video.

12. Provide User and Administrator password protection levels.

13. Up to eight (8) rectangular privacy windows may be configured to mask out specific video from view in the image. Dome camera shall provide image cropping.

14. The camera shall capture image sequences by time lapse intervals or trigger events and transfer the jpeg images via FTP and/or e-mail.

15. Specialized software that enables multiple users to receive alerts via a pop-up window when the camera receives an internal or external trigger shall be available via an optional license upgrade.

16. Dome camera will allow for an optional license upgrade that allows the creation of day and night configuration files for image optimization

D. Camera Networking Requirements:

2. Camera functionality shall be available to users running versions of Java VM and web-browser applications released after January 1, 2004.

3. The camera shall provide integrated support for TCP/IP, HTTP, HTTPS, DHCP, UDP, RTP, RTSP, DNS, ARP, ICMP, NTP, UPnP, ZeroConf, APIPA, UDP multicast, SNMP, FTP, SMTP, Telnet, CIFS protocols.

4. The camera shall provide a multiview function where a single browser page shall be capable of displaying streaming images from up to nine cameras simultaneously.

5. No unique or proprietary client software shall be required for viewing or controlling the camera.

6. The camera shall be user configurable and the administrator may functionally or aesthetically modify the camera’s web pages.

7. The camera shall provide for up to 64 area-of-interest streams that can be independently created of any size and aspect ratio and with any desired display resolution. Substream frame rate can also be configured, up to the maximum frame rate delivered by the camera.

8. The camera shall offer a web interface for quick creation of up to eight substream windows with auto-port configuration of each stream.

E. Camera Recording/Playback Requirements:

1. The IP dome camera shall support on camera storage of time lapse and event recording using micro SD Class 6+ media.

2. Images may be stored at a fixed periodic record rate and/or when triggered by motion and/or external input. Playback shall allow all images recorded to be viewed forward or backward in time.

3. The camera shall record all images in a proprietary file format.

4. The camera shall include pre-event and post-event recording, time-date search, JPEG snapshot, and AVI export functionality.

5. The dome camera shall allow for an optional license upgrade that creates a unique encrypted digital signature that identifies the camera that produced the image and detects if the image has been altered.

F. Event (Alarm) Handling Capability:

1. The IP dome camera shall have an event handler allowing the camera to send an image or video clip to on-camera storage, FTP site, email address, and or network attached storage when receiving an internally or externally generated event.

2. When triggered from an external input or the camera’s motion detector, the camera shall be capable of sending JPEG images via e-mail and/or sequences of images to an FTP server.
3. A relay output shall be available upon the activation of the camera’s motion detector or external relay input. The relay output may also be manually activated from the live view screen.

G. Connections:
1. RJ-45 Ethernet connector (IEEE 802.3af PoE compliant)
2. Punch Down terminal for CAT5, CAT5e, or CAT6 cable
3. Screw terminal: Direct power for 12-24VDC or 24VAC, Trigger In and Trigger Out
4. Analog Service Port: for NTSC and PAL video outputs with 1Vp-p levels
5. Micro SD Card Media Slot
6. Alarm I/O terminals

H. Electrical Specifications:
1. Power Consumption: 5.3 watts maximum
2. Power requirement: 12-24VDC or 24VAC or via IEEE 802.3af Power-over-Ethernet on CAT5, CAT5e, or CAT6 cable

I. Mechanical Specifications:
1. Weight (without lens): 96oz (2839g)
2. Dimensions: 15.36 L x 5.18 W x 9.58 H inches
3. Lens: As required by the application
4. The camera shall feature solid-state components to resist shock and vibration and have no moving parts

J. Environmental Specifications:
1. Temperature range: -4 deg. F to +122 deg. F
2. Environmental Enclosure rating: IP66/NEMA 4

K. Certifications and Approvals:
1. Electromagnetic Compatibility:
   a. Emissions:
      i. FCC, class A part 15
iv. AS/NZS CISPR 22:2002; Class A

b. Immunity:

2. Safety:
a. EN 60950-1:2001 with A11:2004
b. IEC 60950-1:2001

3. Restriction of Hazardous Substance (RoHS): All material and/or components used in the manufacture of the product shall be in compliance with the EU Directive 2002/95/EC RoHS.

L. IP camera assembly shall be IQinVision model IQeye Alliance Pro Series, IQA35NE-B6 or Caltrain approved equal.

2.04 INTEGRATED PTZ IP CAMERA ASSEMBLY

A. Product Description

1. The specified product shall be a high-resolution, PTZ HD Rapid Dome, 10X optical zoom, 360 degree pan rotation and a tilt range of 210 degrees, Day/Night network camera assembled into a rugged, sealed outdoor IP66 and/or NEMA 4X rated enclosure designed for both indoor and outdoor applications. The integrated camera is an industrial grade, color, and full-featured, day/night PTZ HD network camera.

The assembled unit shall consists of 1) a camera and lens module; 2) enclosure; 3) a wall, ceiling, or pole mounting, 4) heater/blower; 5) 120VAC in and 12VDC and 24VDC out power supply; 6) fiber optic media converter; and 7) a power/data connector back box.

The camera and heater/blower shall be powered by 12VDC output of the camera enclosure power supply. The fiber optic transceiver shall be powered by 24VDC from the camera enclosure power supply. The camera enclosure power supply shall be powered by 120VAC brought from the adjacent DC or CER. The 120 VAC power and communications single-mode fiber optic cables shall be run together within the same raceway.

The product shall be designed to meet or exceed industrial and surveillance applications requiring a low power, rugged PTZ video camera with IP network capability. The camera shall have a built-in web server and FTP server.
B. General Product Requirements

1. The specified product shall be a high-resolution, PTZ, Day/Night 1/3-inch HD CMOS optical format, network camera integrated into an all-weather NEMA 4X / IP66 rated enclosure designed for both indoor and outdoor applications.

2. The operating temperature range shall be -20 deg F to +145 deg F.

3. The integrated camera shall be an industrial grade, color, and full-featured, Day/Night, PTZ HD network camera with 1/3-inch optical format.

4. The camera shall be powered directly via 12VDC from the enclosure power supply.

5. The enclosure shall house the camera/lens (while enabling its PTZ features), 120VAC power supply; heater/blower unit; fiber-optic transceiver; and shall allow entry of cables that pass through watertight fittings, which include harsh environment IP67 or better cable seal strain relief connector ports.

6. Various types of mount shall also be available to accommodate various types of mounting surfaces (i.e. wall, ceiling, pole or parapet) and/or mounting installations.

7. The assembly shall provide both input and output alarm trigger connections.

8. The camera PTZ features shall include a built-in 10X optical, auto-focus zoom lens, and 12X digital zoom capability; and capable of 360 degree pan rotation and a tilt range of 210 degrees. Zoom movement speed shall be of approx. 1.0 second (optical wide to optical tele). Maximum pan/tilt speeds of 400° per second and minimum pan/tilt speeds of 0.1° per second

9. The camera shall provide for audio input/output: Microphone/Line In and Line Out

10. The camera assembly shall be vandal and tamper-resistant, featuring camera tampering detection function that alerts the operator if the camera is tampered with. Tampering can include spraying the camera lens, covering it with a cloth, or changing the mounting direction.

11. The product shall be available with any of the Integral 10X (5.1 to 51 mm) F1.8 to F2.1, Auto-focus zoom and IR compensated type lens.

12. To simplify camera setup during installation, an analog output for a display monitor shall be accessible when the lens housing is separated from the camera housing. TCP/IP protocol video output via a RJ-45 Ethernet connection and an NTSC (PAL) analog video output via a BNC connection outputs may be used simultaneously.
13. The fiber optic transceiver/media converter shall convert incoming (over two fiber optic single-mode strands terminated with SC connectors) 100BASE-FX (1310 nm) signal into traditional copper 10/100BASE-TX (RJ-45) signal connecting to the camera network port. The media converter shall be powered by 24VDC output of the enclosure power supply.

C. Camera Specifications:

1. The Day/Night high-resolution color camera specified shall incorporate a progressive scan CMOS imager with a 1/2-inch optical format, with 720p HD resolution.

2. The image resolution shall be minimum 1280(H) x 720(V) pixels. The camera shall produce 30 frames per second (fps) at full 1280(H) x 720(V) resolution in 16:9 aspect ratio. It shall use JPEG, MPEG-4 and H.264 Triple Codec video-compression. The images can be viewed via a standard browser.

3. The camera shall incorporate a built-in 10X optical and 12X digital zoom capability with integrated 5.1 to 51 mm F1.8 to F2.1 auto-focus zoom lens.

4. Minimum light requirement to produce a color image shall be approximately 1.9 lux. When in the Night mode, less than 0.17 lux will produce a black and white image. The video signal-to-noise ratio shall be more than 50dB.

5. The camera shall provide automatic white balance, automatic exposure, gain control, electronic shutter, and backlight compensation.

6. The camera shall be capable of guard tour, which can be used to program up to sixteen (16) presets and moves to each preset sequentially when guard tour is activated. It shall be capable of shadow tour, which is used to learn an operator's PTZ control actions (including those made with a joystick) and then repeats the motions on command.

7. The camera shall be capable of recording image and sound files on the 8 MB of built-in memory or transferring the files to an FTP server. The camera shall have a built-in compact flash card slot to allow the use of additional compact flash memory, or allow the use of the manufacturer specified compact flash wireless LAN card (SNCA-CFW5). The Contractor shall provide for suitable 32GB card (minimum) for additional storage of the camera data.

8. The camera shall have RS-232C, RS-422, and RS-485 interfaces and support the Pelco D and VISCA Protocol. It shall also have a 14-pin I/O interface located on the rear of the base. There shall be four alarm input ports, and two Alarm/relay output ports. The Alarm input port shall be opto-isolated.

9. The camera shall be capable of 360 degree endless pan rotation and a tilt range of 210 degrees with maximum pan/tilt speeds of 400 degrees.
per second and minimum pan/tilt speeds of 0.1 degrees per second. It shall incorporate a built-in 10X optical and 12X digital zoom with zoom movement speed of approximately 1.0 second (optical wide to optical tele). The camera shall have ten (10) user defined presets, with a repeatable mechanical preset accuracy of ±0.045° (typical). It shall be capable of an e-flip function, a feature when the camera passes the down position, electronically flips the image 180 degrees.

10. The camera shall provide for built-in Intelligent Motion Detection (IMD) capability. To minimize false triggers, the IMD shall compare the current image with prior 15 frames within the camera. The IMD algorithm shall allow the camera to discriminate against some environmental noise such as shaking leaves or AGC noise. IMD function shall support at least five Video Motion Filters (VMF) to trigger alarms based on pre-defined rules. The camera shall have a “camera tampering” detection function that alerts the operator if the camera is tampered with. Tampering can include spraying the camera lens, covering it with a cloth, or changing the mounting direction.

11. The camera shall provide on-screen, digital, pan/tilt/zoom on live video.

12. Provide User and Administrator password protection levels.

13. The camera shall be capable of masking up to thirty two (32) privacy areas and provide for image cropping.

14. The camera shall capture image sequences by time lapse intervals or trigger events and transfer the jpeg images via FTP and/or e-mail.

15. The camera shall support IEEE-802.1X authentication.

16. Provide any specialized software required for setup and optimization of the camera.

D. Camera Networking Requirements

1. The camera shall support 10/100BASE-TX communications and incorporate a built-in web server, built-in FTP server, and a built-in FTP client.

2. Camera functionality shall be available to users running versions of Java VM and web-browser applications released after January 1, 2004.

3. The camera shall provide integrated support for TCP, IPv4, IPv6, DNS, RTP/RTCP, RTSP, UDP, ARP, HTTP, HTTPS, ICMP, SMTP, FTPs, FTPc, DHCP, NTP and SNMP (MIB2) protocols. Network security shall be via Password (basic authentication) and IP filtering.

4. The camera shall be capable of supporting up to ten (10) users simultaneously over the network. It shall be capable of dynamic IP address change notification. It shall accomplish this via an email to a specified address or by HTTP when its IP address changes.
5. The camera shall be compliant with the ONVIF (Open Network Video Interface Forum) specification.

6. The camera shall be user configurable and the administrator may functionally or aesthetically modify the camera’s web pages.

7. The camera shall have up to six user-specific level settings. The camera shall have an Adaptive Rate Control (ARC) function when using MPEG-4 and H.264 compression. This function when enabled, shall allow the camera to maintain the frame rate at a reduced image quality when network congestion occurs. Should network bandwidth become further restricted, the frame rate shall then drop automatically to a suitable speed to maintain image integrity.

8. The camera shall offer a web interface, 802.1X authentication; support QoS technology and user configurable port settings.

E. Camera Recording/Playback Requirements:

1. The manufacturer shall offer optional, licensable embedded recording/playback software that allows images to be recorded to an external FTP server or locally to on-camera an asbuilt memory or media card.

2. Images may be stored at a fixed periodic record rate and/or when triggered by motion and/or external input. Playback shall allow all images recorded to be viewed forward or backward in time.

3. Recorded images and data storage shall be no less than 14 days.

F. Camera Event (Alarm) Handling Capability:

1. The camera shall be capable of recording an event as pre and post event images to an asbuilt memory or an on-board Media Card. The camera shall also be able to transfer the event’s JPEG images to an FTP server via File Transfer Protocol (FTP). Events may be triggered using camera motion detection or from an external device input such as a relay.

2. When triggered from an external input or the camera’s motion detector, the camera shall be capable of sending JPEG images via e-mail and/or sequences of images to an FTP server.

3. A relay output shall be available upon the activation of the camera’s motion detector or external relay input. The relay output may also be manually activated from the live view screen.

4. The camera shall support Voice alert function, which can automatically play an audio file stored on the camera by an alarm trigger using motion detection, DEPA Advanced VMFs, camera tampering detection or via a sensor input.
G. Camera Connections:

1. RJ-45 Ethernet connector
2. Punch Down terminal for CAT5, CAT5e, or CAT6 cable
3. Screw terminal: Direct power for 12VDC or 24VAC
4. Analog video: 75 Ohm BNC connector
5. Analog installation setup port: RCA Female
6. Card Media Slot
7. Alarm I/O terminals
8. Audio: mini-jack connectors to support external microphone and active speakers

H. Camera Electrical Specifications:

1. Power Consumption: 30 watts maximum
2. Power requirement: either AC 24V or DC 12V

I. Camera Mechanical Specifications

1. Dimensions: approximately 6 1/8 inches (Dia.) x 9 inches (H) (not including the projecting parts)
2. Lens: As required by the application

J. Camera Environmental Specifications

1. Temperature range: +32 deg. F to +122 deg. F
2. Operating humidity: 20% to 80% (non-condensing)

K. Camera Enclosure Requirements

1. Camera Enclosure shall be designed to provide for a fully functional housing for the CCTV Ethernet network camera specified herein.
2. It shall be designed for CCTV cameras for commercial, industrial, or government applications requiring a rugged, sealed outdoor rated camera enclosure with compatibility to house a broad range of Pan Tilt Zoom (PTZ) or fixed Mini-dome cameras that are commercially available for IP, and High Definition, and CCTV capability. The Camera Enclosure shall be minimal outdoor protection rating of IP66 and/or NEMA4X. The Camera Enclosure shall include harsh environment IP67 or better Cable Seal strain relief connector Ports.
3. The housing will provide power to compatible cameras @ 12 VDC & 24 VDC, and environmental control board for providing power to protective elements which could include two high output 10 CFM Fans, and integrated internal dual ply foil & foam insulation for optimal thermal protection.

4. It shall provide integrated capacity for bolt on wall and/or compatible with optional brackets with capacity for strap mounting pole mounting of enclosure. Provide for provision of any necessary mounting and cable management equipment to provide for a fully functional PTZ Camera assembly.

5. The Camera Enclosure shall be compatible with a media connection cable of Category 5 and/or Category 5 Enhanced and/or Category 6 twisted pair (UTP) cable, using RJ45 compliant connectors, & CCTV coaxial cabling.

6. Housing Power:
   a. Source Supply Voltage @ enclosure: 95-264VAC & 20-30VAC/VDC
   b. Voltage available to power Camera and accessories; 12VDC @ 25 watts max, and 24VDC @ 25 watts maximum. Total sum power to camera or accessories is 50 watts maximum.

7. Housing Mechanical Specifications:
   a. Exterior 14.9” (L) x 13.4” (H) x 11.7” (W)
   b. Interior: 8.6 (dia @ mount base) x 9.3 tall (6.8 dia. max @ lens) (maximum camera size)
   c. Hinged Lower with Captive Stainless Steel Fasteners
   d. Rugged Polycarbonate Housing (0.160” wall)
   e. Clear Acrylic Viewing Lens bubble 6.8” dia. x 3.7” deep
   f. White Semi-gloss finish to PC housing
   g. Protective Urethane foam Gasket Seals
   h. Integrated wall mounting tabs
   i. Integrated Omni Antennae mounting tab on side
   j. Certifications NEMA 4x / IP66

8. Housing Environmental Specifications:
   a. Operating Temperature Range: -20 deg F to +145 deg F
b. Housing shall meet or exceed a rating of NEMA4X and/or IP66

c. Housing shall have two cable entry ports rated to IP67 for power & data cables

d. Housing shall be suitable for deployment into wide range of moderate environments of Residential, Commercial, Industrial, Marine, Desert, and other indoor & outdoor installations.

L. Industrial Mini Media Converter Requirements:

1. Industrial Mini Media Converter shall be designed to provide for a fully functional fiber-to-copper Ethernet communications conversion for the CCTV Ethernet network camera specified herein.

2. Industrial Mini Media Converter shall provide for integration of fiber optic cabling into industrial or outdoor 10/100 UTP Ethernet networks. It shall feature wide operating temperature range, low-voltage DC power, multiple mounting methods and lifetime warranty, and shall be designed for harsh outdoor or industrial applications.

3. General Features:

   a. Unit and Port LEDs to provide quick status
   b. Auto-Negotiation
   c. Fixed Full-Duplex on fiber
   d. AutoCross™ on copper port
   e. Link Pass Through
   f. Automatic Link Restoration
   g. Far-End-Fault
   h. DC Powered

4. Specifications:

   a. Fiber Ethernet Signal: 100BASE-FX, 1310 nm with link budget: 16.0 dB and max distances: 12.4 mi
   b. Fiber Connector type: SC
   c. Fiber type: Single Mode
   d. UTP Ethernet Signal: 10/100BASE-TX
   e. UTP Ethernet Connector type: RJ-45
f. Status LEDs: PWR (Power); FX-Link/Act (Fiber Link/Activity); TX-Link/Act (Copper Link/Activity)

g. Dimensions: Width: 1.8" x Depth: 3.3" x Height: 0.85"

h. Power Consumption: 2.5 watts

i. Power Sources: 12-48VDC

j. Operating Temperature: -40°C to 75°C

k. Humidity 5% – 95% humidity non-condensing

l. Regulatory Compliance FCC Class A, CISPR22/EN55022

m. Class A, EN55024, CE Mark

n. Warranty: lifetime

M. The following equipment shall be used:

1. IP camera shall be Sony model SNC-RH124 or Caltrain approved equal

2. IP camera outdoor housing shall be Dotworkz model D2 Tornado with MVP Multi-Volt Platform or Caltrain approved equal

3. The Industrial Mini Media Converter shall be Transition Networks model M/E-ISW-FX-01(SM) or Caltrain approved equal

2.05 CABLEING

A. Furnish and install a UTP Category 6, 4-pair cable with RJ45 connectors between the assigned Distribution Cabinet or CER and the camera location.

B. Furnish UTP cables that are terminated at the CCTV camera end and at the surge suppressor at the cabinet’s or CER’s point of entry. Install the cable from the CCTV camera end to the cabinet termination point leaving sufficient slack in the cable for normal camera operation and maintenance. Provide slack cable in the CCTV cabinet in accordance with the design.

C. Provide cables to connect from the UTP or composite cable termination points (i.e., termination point with surge suppressors) to the redundant Ethernet switch located in the assigned Distribution Cabinet or CER.

D. Where design prohibits use of UTP cabling (due to cabling distances exceeding 300 ft or high EMI levels) furnish, install and terminate a 4-strand single-mode fiber cable. Such installation shall be accompanied by the corresponding installation and termination of the CCTV 120VAC UPS-backed power wiring and shall be routed in separate raceways from the power wiring for the station’s remaining subsystems. The corresponding standard Media Converter or Media Converter with 1EEE802.3af PoE/PSE supply (i.e. Etherwan model EL1032 or Caltrain approved equal) shall be implemented on the receiving end as per the project design.
E. As a part of the Design Submittals, prior to installation and termination of the CCTV System conduits and cabling, submit to Caltrain for approval the conduit and cabling labeling scheme. See Caltrain Standard Specifications Section 17050, Basic Communications Equipment, Material and Methods.

2.06 CCTV MOUNT

A. Furnish and install the CCTV camera assembly-mounting arm at locations as shown on the Contract Drawings and all necessary attachment hardware, grounding and miscellaneous hardware. The mounting arm shall mate with the CCTV assembly support pole.

B. A conduit passageway through the pole at the camera-mounting arm shall be used to pass the UTP and/or, where applicable, other cables through the pole to the CCTV mounting arm and then into the CCTV camera assembly.

C. The cabling may be a combination CCTV communication and power cables. The arm shall completely conceal all cables so there is no exposed wiring outside the pole, cabinet and camera.

D. The attachment of the CCTV camera assembly to the mounting arm and the electrical connections and the attachment of the arm to the camera support structure shall be in accordance with the camera manufacturer's installation recommendations. The arm mounting to the support pole shall not use “U” bolts or banding as the attachment hardware.

E. The design of the attachment hardware shall provide a secure connection between the pole and the camera-mounting arm. The design and fabrication of the CCTV mounting arm to support pole hardware shall be submitted for review and approval to the Engineer. Provide a Caltrain approved CCTV assembly-mounting arm that meets the structural, functional and aesthetic needs of the project. The required mounting arm may or may not be an off the shelf product provided by the CCTV camera assembly manufacturer or vendor. It shall be acceptable to design and have fabricated a specialty arm that shall meet the specific needs of the project subject to Caltrain’s approval.

2.07 NETWORK DIGITAL VIDEO RECORDER (DVR)

A. General Product Description:

1. This description lists the technical specifications for the station video Nextiva Recorder Server.

2. All software components shall be part of the manufacturer’s standard software product offering. All software components shall be thoroughly tested and proven in reference installations. The Network Video Recorder solution shall be DHS certified as an anti-terrorism technology.

3. The station DVR solution shall have flexible, open architecture built on accepted industry standards that support a Workgroup Windows Environment; Active Directory Domain Environment and unified workstation logon based on Windows authentication. The station DVR shall have flexible configuration architecture that facilitates video
resolution transcoding in order to stream video in a low bandwidth connection to the Review and Client SDK applications.

4. The specified product is an all-in-one multichannel (a channel per a camera) Network Video Recorder, providing for recording, local and remote surveillance; intelligent video analytics and enhanced file security by digital watermark required by the station CCTV System.

5. For recording functions, the device supports continuous/ manual/schedule recording; alarm recording (by motion detection or sensor triggered); multiple alarm recording schedules; megapixel recording; Motion-JPEG, MPEG-4, MxPEG and H.264 recording; audio recording (vary by camera models).

6. For surveillance functions, the device supports diversified modes for live monitoring; smart control of PTZ cameras and auto cruising; event notification on monitoring; real-time SMS and email alert; multi-channel playback at different speed; easy data search by date & time, timeline, event, and intelligent video analytics (motion detection, foreign object, missing object, out of focus, and camera occlusion).

7. The station DVR shall provide support for IP (network) cameras from multiple third party manufacturers and various encodings including MJPEG, MPEG-4 and H.264.

8. The station DVR shall support video motion detection natively. This operation can be executed by the edge device or the IP Camera. Enabling motion detection shall be performed either: on a continuous basis; scheduled for particular times, dates, days, months, etc.; defined areas of interest through an easy-to-use user interface using simple editing tools; and/or at a defined level of sensitivity.

9. The Recorder shall use standard COTS (Commercial Off-The-Shelf) server technology and storage attachments including certified for EMC storage solutions. Video storage implementations for the station DVR shall be either be internal, external SCSI-attached, external Fibre Channel-attached, or external iSCSI SAN (depending on the application’s functions, storage and performance requirements).

7. The station DVR solution shall be capable of supporting multiple site locations linked via LAN / WAN connections.

B. Station DVR Interfaces:

1. The station DVR shall support the ability to support third-party IP cameras via the Service SDK which can be used to develop adaptors for any IP camera.

2. The station DVR shall support H.264, MJPEG and MPEG-4 compression from edge devices and IP cameras.

3. The station DVR shall support H264 de-compression on the Workstations.
4. The station DVR shall support an unlimited number of dry-contact inputs.

5. The station DVR platform shall support an unlimited number of dry-contact outputs.

6. The station DVR shall operate over a Local Area Network (LAN)/Wide Area Network (WAN), using a standard Ethernet 100/1000 Base-T connection.

7. The station DVR shall support either or both Unicast or multicast over the enabled network.

8. The station DVR shall transmit video using the UDP/IP or TCP/IP communication protocol.

9. The station DVR shall transmit all command and control messages using the TCP/IP protocol.

10. The station DVR shall generate alerts on disabled camera inputs.

11. The station DVR shall support the ability to support third-party keyboards via the Service SDK which can be used to develop adaptors for any third-party Keyboard.

12. The station DVR shall support additional PTZ Keyboard Camera Commands such as:
   a. Call up Patterns
   b. Camera Menu Commands
   c. Auxiliaries
   d. Home Position
   e. Flip Camera 180 degrees

13. The station DVR shall support all station CCTV equipment installed under the current project.

14. The station DVR equipment shall be fully compatible with the existing Caltrain Nextiva CCTV Hardware and Software Head End located at Caltrain Headquarters in San Carlos.

C. Station DVR Requirements:

1. The station Recorders shall store video on COTS equipment using hard drives as storage medium. The recorders also have the capability to support the attachment of external storage devices.

2. The station Recorders shall be certified with optional EMC storage solutions.
3. The station Recorders shall be certified to Record in VMware environment.

4. The station Recorder Server shall be configured to run Master Server functions, Recording, Storing, Media Gateway Server, Live View and the Review applications simultaneously (including simultaneous support of multiple users/streams/views) for cost-effective deployments. The Contractor shall select vendor-recommended hardware and software for the station DVR to be able to support such performance requirements for multiple simultaneous tasks operations (with no task interfering with any other task).

5. The Recorder shall run autonomously and continue to Recorder once configuration is received.

6. The Recorder shall support the ability to fail-over to another recorder or group of Recorders dynamically without user intervention.

7. The station Recorder Server shall have the ability to record simultaneously all station cameras at their maximum resolution and the lowest level of compression (maximum quality); and store the recorded CCTV video at the local station storage for at least 14 days. Also, to support future growth, the performance and storage of the station DVR equipment shall be rated to handle additional 50% of similar station CCTV equipment. As a part of the design submittals, submit all necessary calculations for performance and storage requirements of the CCTV system and identify adequate and up-to-date equipment/software similar to the lists below.

8. The station DVR and, if applicable, external storage shall utilize High Reliability and Smart Features, such as:
   a. Advanced RAID (RAID 5/ 5 + hot spare/ 6/ 6 + hot spare/ JBOD) with hot-swap design
   b. Large storage capacity for long-term recording
   c. Intelligent auto power on when power resumes after power outage
   d. Supports UPS for 24x7 service
   e. Two Gigabit LAN ports for failover, load-balancing, or multi-IP setting

9. The minimum requirements for a server hosting Master Server and Recorder services with internal storage are listed below.
   a. Processor and Speed: Vendor recommended microprocessors based on up-to-date available hardware and to meet functional requirements above
b. Memory: Vendor recommended memory type and size based on the up-to-date available hardware and to meet the functional requirements above

c. Boot Drive: 2 X 80 GB SATA in RAID 1 configuration

d. Video Storage Drives: SATA with capacity and redundancy as specified

e. Operating System:
   i. Win2003 SE Server R2, SP1 or SP2
   ii. Windows 2008 SP2

f. Video Card: 128 MB RAM, 1024x768

g. NIC: 100/1000 BASE

h. 8X DVD Writer

10. The minimum requirements for a server hosting a Master Server and Recorder with external storage for video are listed below:

a. Processor Speed: Vendor recommended microprocessors based on up-to-date available hardware and to meet functional requirements above

b. Memory: Vendor recommended memory type and size based on the up-to-date available hardware and to meet the functional requirements above

c. Boot Drive: 2 X 80 GB SATA in RAID 1 configuration

d. Operating System:
   i. WIN XP + SP2
   ii. Win2003 SE Server R2, SP1 or SP2
   iii. or Windows 2008 SP2

e. Video Card: 128 MB RAM, 1024x768

f. NIC: 100/1000

g. 8X DVD Writer

11. Media Gateway Server requirements:

a. In order to enable live views at the Caltrain Headquarters headend of the station's high resolution cameras over the existing Caltrain low-bandwidth WAN links (partial T1 lines
between stations and the Caltrain Head End CCTV equipment), the station DVR shall provide for the Media Gateway functionality.

b. The Media Gateway Server shall be capable of running all video transcoding and WAN transport services. The Media Gateway Server shall transcode received video from IP cameras or edge devices at a certain resolution and then convert and send the low resolution video through a bandwidth limited WAN link.

c. The Media Gateway shall properly packetize video to transverse NAT’s and Firewalls using IP with a maximum of 2 ports.

d. The Media Gateway shall support Review User Priorities when multiple remote Review user requests for video exceed the bandwidth of the WAN/LAN link.

D. Station DVR General Software Requirements

1. The station DVR shall have a graphical user interface (GUI) that allows the user to quickly configure and apply the following parameters:

a. All cameras configurations

b. All recorder configurations and resolutions

c. All work schedules

d. User and access rights and privileges

e. Create schedules and apply them to specific camera groups

f. Configure cameras and recorders individually and as a group in system components

g. Support event management and recording; establishment of rules and follow up actions

h. Video storage locations, settings and schedules; and management of long-term storage and archiving

i. Add and edit interactive site plans and Maps

j. View live video, retrieve recorded video, and export video into desirable media (authenticate video to enable users to verify that the video has not been modified since it was recorded). This includes viewing of live or historical alarm events and the associated video by scanning of recorded video for activity thru an energy graph that indicates levels of activity.

k. Manage multiple windows (up to 16) and the associated rules and priorities
l. Control PTZ cameras and configure PTZ presets/patterns/tours

m. Group cameras and maps at and define multiple levels of groups and maps

n. Support digital zoom on live or recorded video, without requiring a video pause

o. Manage images’ date and time, text annotation, adjust the brightness and/or contrast; smooth, sharpen, grayscale and other filtering

p. Select video to be exported and from a precise start time and end time

q. Save the image to disk in various standard file formats

r. Be video analytics ready

s. Support failover/redundancy (where required)

t. Configuration of the Media Gateway functionality for downscaling high resolution video-streams into resolutions of lower quality and lower bandwidth requirements for live view of such images at the Caltrain CTV Head End via the low bandwidth (partial T1) WAN links to the stations

u. Support setup of health check settings for live monitoring and detailed system performance metrics on system components, including all server-side software applications, edge devices, and cameras (including cameras’ out-of-focus, tampering detection and full/partial blockage of the view)

2. Prior to implementation and configuration of the station DVR, for each Design Review Level, submit for Caltrain’s approval the proposed settings for all software functions described above.

E. Product, Server and Storage requirements:

1. The station DVR shall be Verint Nextiva Recorder Server with internal storage on the Dell PowerEdge R710 platform (or the most current approved substitute), and the Nextiva Recorder Server with external SCSI or Fibre Channel storage on the Dell PowerEdge R410 platform (or approved up-to-date hardware platforms recommended by the vendor). The chosen platforms shall meet the storage and performance requirements listed within these specifications (based on the Contractor calculations and approved by the Caltrain).

2.08 UPDATES TO THE CALTRAIN EXISTING CCTV HEADEND SOFTWARE

A. As a part of the Design Submittals, submit to Caltrain for approval the IP addressing scheme and security scheme for all station CCTV System elements.
B. Caltrain will program into the existing Caltrain CCTV Head End Verint software the new station CCTV cameras, DVRs and other CCTV network elements. The Contractor shall assist the Caltrain personnel with the integration (and the associated configuration/testing) of the station CCTV equipment into the existing Caltrain CCTV Head End.

PART 3 - EXECUTION

3.01 INSTALLATION

A. At locations where new cabinets are installed, new UPS electrical services shall be installed as shown on the plans. The new electrical services shall be sized to accommodate the equipment to be installed in the cabinets.

B. Where multiple subsystems devices share the same pole or location, provide separate Category 6 or fiber optic cabling and conduit per device. Subsystem devices shall not share cables conduits, or other pathway.

C. Integrated Camera Assembly: Install an integrated camera assembly, UTP or composite cable, camera interface panel, and camera-mounting arm at locations as show in the Contract Drawings.

D. Where cameras are located less than 9 feet above the surrounding ground surface physical protection shall be utilized to protect them from vandalism.

E. No field cabinets shall be used for the CCTV at camera positions. The CCTV camera shall stand alone with Category 6 or fiber optic cable connectivity to its assigned Distribution Cabinet or CER (whichever is closer or practical).

F. CCTV Assembly Installation:

1. Mount the CCTV assembly on the mounting arm in accordance with the manufacturer's recommendation and at locations as shown in the site specific drawings. Install the camera assembly UTP or composite cable in accordance with the routing as shown in the Contract Drawings. Make all necessary cable connections.

2. Feed all cable connections from the CCTV Camera assembly leaving sufficient slack in the cable for normal movement and maintenance of the CCTV camera assembly. After installation and cable termination an initial test shall be performed to confirm that the camera has been installed properly and functions correctly from the CCTV cabinet location. This initial test is not a replacement or substitute for any acceptance test.

3. Perform the CCTV assembly manufacturer's initial power-on test in accordance with the manufacturer's recommendation. Ensure that the camera assembly receives all pan/tilt/focus/zoom telemetry settings by exercising the camera assembly to verify each telemetry function.

4. Perform additional testing conforming to any other CCTV camera manufacturers recommended procedure to confirm that the initial functionality is operational. With either a test monitor or other device as
recommended by the CCTV Camera assembly manufacturer confirm that a video image is present from the installed camera assembly.

G. CCTV Mount:

1. Furnish and install a mounting bracket for a pole mount, which includes the pole attachment hardware, clamps, bolts and bracket arm. “U” bolts and strap supports will not be allowed.

2. Mount the CCTV mounting bracket at the cardinal direction as shown in the Contract Drawings. Ground the mounting arm as shown in the Contract Drawings.

H. CCTV Connectivity:

1. Install CCTV camera to include UPS power receptacles, dc power supply, terminal strips, lightning and voltage suppressors, grounding strips, and internal wiring.

2. Connect camera UTP or fiber-optic cable connector(s) to integrated camera assembly per manufacturer installation manual. Terminate camera cables in cabinet as follows:

   a. Power: Terminate ac/dc+, ac/dc-, and ground wires and connect to camera power supply surge suppressor provided in cabinet. All CCTV equipment shall utilize UPS backed power.

   b. Fiber Optic Communications: Fiber Optic cabling shall be 4 strand single-mode cable suitable for outdoor installations and made of non-metallic elements. Terminate all 4 strands of the single mode fiber optic cable with SC connectors at each end of the cable. Connect two of these strands to the fiber optic transceiver / media converter inside the camera enclosure and at the corresponding media converter at the Station LAN redundant Ethernet switch within DC or CER (whichever is closer). These two strands will be used for the video communications and the remaining two strands will serve as “ready to use” spare.

   c. Video: During the initial field setup, if available, terminate coax cable with BNC connector as per manufacturer recommendations. For UTP cable, use RJ45 connectors.

   d. Wiring, Conductors and Terminal Blocks: Use stranded copper for all conductors, including those in jacketed cables, except for earth ground conductors, which shall be solid copper. Neatly arrange all wiring, firmly lace or bundle it, and mechanically secure the wiring without the use of adhesive fasteners. Route and secure all wiring and cabling to avoid sharp edges, and conflicts with other equipment or cabling. Route camera copper communications wiring separately from 120Vac wiring. Terminate all wiring on a terminal block, strip, buss bar or device clamp or lug; do not splice any wiring. Use a minimum #12 AWG for all conductors for 120 Vac circuits except for the 120
VAC supply circuit for the camera and pan/tilt unit. The gauge of the power wiring for the PTZ camera assemblies shall be determined by the voltage drop and conduit fill ratio calculations. The minimum gauge for the PTZ camera assemblies’ power wiring shall be #16AWG. Install all wiring as shown in the Contract Drawings.

e. Neatly dress the cables in the cabinet, and reach the connectorized end to the mating connectors on the camera assembly with 3 foot slack. Cut unused conductors in the cables to the same length as the assigned conductors. Bend back the unused conductors over the outer jacket and individually tape them in a manner to prevent pinching by the CPC strain relief clamp.

f. All cables used in the cabinet are UL-listed tray cable with PVC/nylon insulation and UV-resistant PVC outer jacket rated for 600 V, 194 degrees F dry; 167 degrees F wet and wet/dry direct burial use. All furnished wiring used to complete the installation are to be rated at or above these minimum values. Video signal cable, when used, shall be high-flexibility double-shielded with tinned copper braid, #22 AWG stranded copper center conductor, and PVC outer jacket. Use BNC connectors on the video signal cable only as recommended by the cable manufacturer. Confirm during testing that this two-way data path is present and active. For IP fixed cameras, UTP cable shall be TIA/EIA Category 6, 4-pair solid conductor, rated CMR and placed in metallic conduit between the network distribution cabinet and camera assembly.

g. Dress and route grounding wires separately from all other cabinet wiring. Install grounding wires with the absolute minimum length possible between the suppressor and the ground buss bar. Label all surge suppressors with silk-screened lettering on the mounting panel.

h. The cabinet shall be furnished with three-stage transient surge suppressors for protecting the camera control/feedback, video output, and power supply lines. These suppressors shall be in addition to the suppression provided by the CCTV camera equipment. For IP fixed cameras, UTP shall be protected at the network distribution cabinet with 4-pair solid-state protection rated for Category 6.

i. Install electrical cables used for video, control, communications signaling and power supply as shown in the Contract Drawings. Do not splice any cable, shield or conductor used for video, control, communications signaling, or power supply. Identify all conductors of all cables by color and number. Identify the conductor function in as-built documentation included in the cabinet documentation. Terminate cable used for analog video signaling in BNC connectors. After termination and dressing the cables in the cabinet, neatly coil and store a minimum of 3 foot
(.61m) of cable slack in the bottom of the cabinet. Cut unused conductors to a length that can reach any appropriate terminal. Bend back the unused conductors over their outer jackets and individually tape them.

j. Where used, provide a single UPS 120 / 24 Vac (60 Hz) power source to the camera assembly from the equipment cabinet to supply both the camera and the heater in the camera housing.

k. Install cabling between the CCTV camera assembly and the network distribution cabinet inside support poles, conduit, or structures as shown in the Plans. Use weather heads on all nipple and conduit openings. Neatly install and route cabling to minimize movement in the wind and chafing against the pole, device or bracket. Form a drip loop at the weather head and route cabling to minimize water entry into the cable connector. Lash cabling mounting arm and route into camera and pan-tilt unit.

I. Connect data cables from the CCTV equipment to the station LAN and configure the station DVR with approved settings for cameras, storage and other CCTV system related settings to make complete and fully functional station CCTV system.

J. Assist Caltrain personnel with incorporation of the new station CCTV equipment into the existing Caltrain CCTV system to ensure full integration of the new CCTV equipment.

3.02 TESTING AND INSPECTION

A. Acceptance testing consists of three phases: Field Installation Testing, CCTV System Site Testing, and Burn-in Period.

B. Field Installation Test:

1. Perform the Field Installation Test as an onsite test of the complete field installation assembly less the communications components. No acceptance testing at a given site can begin until all work associated with that site is complete, not including the communications components. For the field equipment installation test, a PC laptop system, camera control receiver-vendor control software (Caltrain provided) and a 13-inch or larger color video monitor shall be used to demonstrate full operation of the CCTV site. Proper operation is to include pan, tilt, focus, zoom, iris, and position feedback and communications address configuration.

2. Perform local field operational tests at the device field site and end-to-end video streaming tests in accordance with the test procedures below:

a. Verify that physical construction has been completed as detailed in the plans

b. Inspect the quality and tightness of ground and surge protector connections
c. Check power supply voltages and outputs

d. Connect devices to the power sources

e. Verify video image presence and quality with a vector scope and a portable NTSC approved monitor and DVD

f. Exercise the pan, tilt, zoom, focus, iris opening, manual iris control selection and operation, low-pressure alarm (if present), preset positioning, and power on/off functions

g. Demonstrate the pan/tilt speed and extent of movement to meet all applicable standards, specifications, and requirements

h. Demonstrate the ability to support IP unicast and multicast SAP and QoS

i. Configure the DVR IP addresses for video and data input

j. Verify proper voltages for all power supplies

k. Interconnect the communication interface device into the communication network’s assigned fiber optic cable and verify network transmission activity.

C. Test the installed CCTV assembly at the bottom of the pole from the camera cabinet using test procedures specified herein and recommended by the CCTV camera assembly manufacturer.

D. CCTV System Site Test:

1. After the completion of the associated copper or fiber optic communication connection between the CCTV camera assembly and the associated DC cabinet to the station equipment room (CER), perform the CCTV System Site Test to demonstrate proper CCTV system performance at the CER. The CCTV System Site Test shall be performed only after successful completion of the field installation test. Proper operation is to include a satisfactory video image, areas of coverage, pixel per foot level of detail, camera/lens control, if applicable, PTZ controls, and communications operation from each CCTV site to the CER and Caltrain San Carlos CCTV Head End.

2. Test of all software functions of the station DVR for compliance with the Caltrain Engineering approved requirements and settings for the Station DVR hardware and software.

3. The demonstration shall use the central CCTV software and control center and communications system to demonstrate the compatibility of the CCTV equipment installation in its permanent configuration. Proper operation is to include a demonstration of proper data communications integrity with a communication protocol analyzer.
4. Caltrain shall witness and record the test data, date and time of successful completion of the test.

E. Burn-in Period:

1. The Burn-in Period starts after the Caltrain Engineering accepting the completion of the Field Installation Test and completion of the CCTV System Acceptance.

2. Any failure determined to be the result of faulty installation materials or workmanship shall be cause to restart the burn-in period. Correct any faulty material or workmanship that results found during the burn-in period. At the successful conclusion of the burn-in period Caltrain will accept the installation as complete.

3. The burn-in period shall determine if the system is capable of recording and storing the station camera images at the highest resolution and at the highest frame rates required by the Station Design.

4. The burn-in period shall be for a continuous 30 days and shall be performed for the station CCTV equipment as a whole.

F. Test the new station CCTV equipment is fully compatible with the existing Caltrain CCTV Head End as per Caltrain approved requirements and settings.

END OF SECTION
SECTION 18000
GENERAL SIGNAL REQUIREMENTS

PART 1 - GENERAL

1.01 DESCRIPTION
A. Section includes general procedures and requirements for the planning, manufacturing, installation, removal, relocation, modification, testing, placing in service, and documentation of as-built conditions of the various signal systems.

1.02 GENERAL
A. Provisions of this Section apply to all Sections of Division 18, Signals.
B. Modify existing equipment and material as shown on the Contract Drawings to interface with the existing and proposed signal system.

1.03 REFERENCE STANDARDS
A. Electrical equipment, unless specifically excluded herein, shall conform to the standards of the National Electrical Manufacturers Association (NEMA), The Underwriters' Laboratories Inc., (UL), the Electrical Testing Laboratories (ETL), the National Electrical Testing Association, Inc. (NETA), or the Electronic Industries Association (EIA), wherever applicable. Unless specifically excluded herein, materials and workmanship shall conform to the requirements of the National Electrical Code; California Administrative Code, Title 8, Chapter 4, Subchapter 5, Electrical Safety Orders; Caltrain Signal Standards, and any applicable local ordinances.
B. The following General Orders (G.O.) of the State of California Public Utilities Commission (CPUC) shall apply:
1. G.O. 26 Clearances on Railroads and Street Railroads as to Side and Overhead Structures, Parallel Tracks, and Crossings
2. G.O. 52 Construction and Operation of Power and Communication Lines for the Prevention or Mitigation of Inductive Interference
3. G.O. 75D Protection of Crossing at Grade of Roads, Highways, and Streets with Railroads
4. G.O. 88 Alteration of Existing Grade Crossing of Public Roads, Highways, and Streets with Railroads
5. G.O. 118 Construction, Reconstruction, and Maintenance of Walkways and Control of Vegetation
C. 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

In addition, the Contractor shall be responsible for adherence to all of the above rules and reporting requirements, including those regulations which require pre-employment 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.

D. Manual on Uniform Traffic Control Devices (MUTCD), Part 8, Traffic Control Systems for Railroad and Light Rail Transit Grade Crossings, shall apply.

E. In addition to the regulations and code requirements specified in this Section, materials and equipment for the signaling systems shall conform to the standards and recommendations of the Communications and Signals Manual of Recommended Practices of the American Railway Engineering and Maintenance of Way Association (AREMA), hereinafter referred to as the AREMA C&S Manual, except that where the Manual uses the word “should” the Contractor shall substitute the word “shall”.

1.04 SYSTEM DESCRIPTION

A. Owner-furnished materials for signal systems, if provided, along with delivery points or location of this material for pickup, are listed in the attachments to Section 01600, Materials. Refer to Section 01600, Materials, for Contractor responsibilities for receiving, accepting, and transporting Owner-furnished materials. Assemble and install this material as shown on the Contract Drawings.
B. Provide all additional materials and installation services required for complete working signal systems, as described herein, and as shown on the Contract Drawings, including any equipment not designated as being relocated or designated as Owner-furnished.

C. All materials and equipment for installation and for interconnection of the various signaling systems shall be fabricated, furnished, and installed as indicated on the Contract Drawings and specified herein.

D. The Contract Drawings represent a final design utilizing systems, components, and materials that meet the Contract Specifications. Contractor may provide equivalent systems, components, and materials subject to the approval of the Engineer. If equivalent systems, components and materials are provided, the Contractor shall provide an alternate detailed final design as specified herein under Design Submittals.

E. Provide systems that are compliant with applicable rules and regulations of 49CFR, parts 234, 235, and 236, and CPUC GO 75D. Refer to Design Submittals herein for Contractor’s responsibility to indicate any corrections or modifications to the Contract Drawings final design that the Contractor may determine are required to conform to these rules and regulations.

F. The Contractor shall be represented at all design meetings held with the Engineer by a signal engineer qualified in the design and application of the signaling equipment the Contractor proposes for use on this project.

G. No circuit is considered to have met the requirement of these Specifications for function and safety until it has been properly tested and verified in the field. Any circuit changes made to meet the functional and safety requirements of these Specifications shall be considered as included as part of the Work.

H. Provide continuous train control and highway grade crossing warning during all phases of rail construction. At no time shall the work of the Contractor cause delay to train operations, cause an unsafe signaling condition to exist, or reduce the effectiveness or quality of the existing or new grade crossing warning systems.

1. Refer to Design Submittals herein for requirements for submittal of plans for providing wayside signaling and highway crossing warning systems protection during the Work and plans for point protection and fouling when crossovers are installed or removed. Alternate methods shall conform to CFR 49, Part 234, Part 236 and all local ordinances.

I. Provide rail bonding for all new, temporary, and relocated turnouts as shown on the Contract Drawings or as required by the Engineer. Provide rail bonding, as necessary, to maintain existing systems during construction.

J. Protect existing signal cabling and, where necessary, relocate existing cabling in order to prevent damage during track installation and surfacing.
K. Refer to Section 01720, Contract Record Documents, and additional requirements specified herein. Record the final as-built conditions of the signal systems for each system.

L. Perform and document all tests and inspections in accordance with CFR 49 regulations, the AREMA C&S Manual, the PCJPB Maintenance and Test Manual, and these Specifications.

M. Refer to Section 01005, Contractor’s Personnel and Equipment, and additional requirements specified herein. Provide at least one qualified signal person to accompany any on track equipment, and remove, relocate, or disconnect and reconnect any signal equipment that could be damaged by on track equipment.

N. Coordinate installation, inspection, and testing of new Owner-furnished material with the Engineer. Notify the Engineer in writing 30 days prior to any installation, inspection, and testing as part of this coordination.

O. Perform acceptance testing and commissioning of the signal system as a normal part of the Work.

P. Contractor furnished software and components shall be new and manufacturer certified.

Q. Remove, salvage, retire, relocate, furnish, and install project related devices as indicated in the Contract Documents and as required to complete the Work.

1. To retire a grade crossing or a control point, first bulletin it as retired and then take temporary measures with the existing equipment, as required, before removing and salvaging it.

R. Refer to Section 02300, Earthwork, for provisions for excavation and requirements for shoring of excavation as specified in Section 02200, Support of Excavation.

S. Refer to Section 01047, Utilities and Systems Coordination, for requirements for locating and protecting existing utilities. Details of signal cable runs, conduit runs, and pullbox installations including number, size, and type of cable are shown in the signal drawings of the Contract Drawings. Information regarding new conduit runs and pullbox installations appear elsewhere in the Contract Drawings. Conduit runs and pullbox locations, as shown, are the preferred locations. In case of conflict between the signal drawings and other Contract Drawings, the signal drawings take precedence as to detail, and in the event of conflict as to placement of equipment, the Engineer will determine the correct placement.

1. Make any minor deviations in location, minor meaning within 10 feet of the location as shown on the civil drawings of the Contract Drawings, as part of the Work. Deviations in excess of 10 feet may be subject to the changes provisions of General Provisions GP4, Scope of Work.
T. All underground signal cables shall be in conduit or trough except for the final connection of the twisted two conductor number six track cable to the twisted flex to the rails.

1.05 FAIL-SAFE DESIGN REQUIREMENTS

A. As used in these specifications, the fail-safe principle shall mean that whenever an equipment failure, human error or failure to act, or adverse environmental condition affects the specified operation of a system involved with the safety of life or property, that system shall revert to a state known to be safe.

B. Failure of a circuit or equipment that results in an indication of a dangerous or restrictive condition, whether or not there is in fact actual danger, shall have met the fail-safe requirements. Conversely, a failure that results in an indication of safe or nonrestrictive condition when, in fact, a dangerous condition may exist shall not have met the fail-safe requirements.

C. Vital applications, such as detector locking of switches, shall be based on the following principles that permit the attainment of fail-safe operation in all known or discovered failure modes:

1. Closed Loops: Fail-safe circuits shall employ the closed loop principle and shall protect against open circuits, shorts, or any combination thereof.

2. Vital Relays: Relays used in vital circuits

3. Vital Circuits: All line circuits, which energize a vital relay, shall be two-wire, double-break circuits and shall be energized from an ungrounded direct current (dc) power supply line circuits are defined as any circuit that leaves the housing in which the relay or microprocessor input is controlled by that circuit from the relay or microprocessor input to the energy that controls that input.

4. Grounds: Components or wires becoming grounded shall not cause an unsafe condition.

5. Spurious Oscillations: Any amplifier, generator, or device element, active or passive, breaking into spurious oscillations shall not cause an unsafe condition.

6. Filters: Filters used in fail-safe circuits shall be designed to prevent undesired signals from appearing at the filter output at levels which could cause an unsafe condition.

D. Equipment failures and conditions which shall be considered in producing a fail-safe design shall include the following, at minimum:

1. Relays (non-vital): Open coil, fused contacts, high contact resistance, shorted coil, armature sticking, contacts sticking, or broken spring
2. Relay (vital as defined by the AREMA C&S Manual): Open coil, shorted coil, or high contact resistance

3. Transformers: Open primary, open secondary, shorted turns, primary-to-secondary shorts, or combinations thereof

4. Capacitors: Short, open, or leakage

5. Resistors: Increase or decrease in resistance

6. Transistors: Short, open, leakage, or loss of Beta

7. Diodes: Short, open, or reverse leakage

8. Coils: Open or shorted turns

9. Loss or degradation of power sources

10. Appearance of abnormal signal levels, electrical noise levels, frequencies, and delays

11. Effects of electrical interference

12. Absent or abnormal input signals

13. Opens or shorts in internal circuitry at inputs and at outputs

14. Mechanical vibration or shock

15. Drift or instability of amplifiers, receivers, transmitters, oscillators, switching circuits, and power supplies

16. Deterioration of contacts, connectors, terminals, solder connections, printed circuits, circuit adjusting devices, and mechanical devices

E. Fail-safe equipment proposed for vital signaling applications shall have been proven with a minimum of 5 years of successful rail service operation in the United States of America.

1.06 ENVIRONMENTAL PARAMETERS FOR EQUIPMENT

A. Contractor provided material and equipment shall be fully operable with no impairment resulting from the effect of the environment throughout the range of worst values indicated below. The general operating environment shall be considered to be in salty atmosphere and in generally sunny weather.

B. Ambient outdoor temperature range: From minus 40 degrees F (minus 40 degrees C) to plus 160 degrees F (70 degrees C).

C. Relative humidity range: From zero to 100 percent.

D. Maximum rainfall: 4 inches in 24 hours and 1.5 inches in 1 hour.
E. Maximum wind velocity: 100 miles per hour.

F. Seismic Zone Location of Work Site: Seismic Zone 4 as defined in the Uniform Building Code.

G. Isokeraunic Level: Five per year.

1.07 DESIGN SUBMITTALS

A. Undertake no work without the prior submittal to and approval by the Engineer of the relevant plans and procedures.

B. Alternate Detailed Final Design: Submit proposed equivalent systems, components, and materials, if proposed, for Engineer's approval no later than 90 days after Notice to Proceed. Utilize, at a minimum, the symbols, nomenclature, and CADD standards depicted on the Contract Drawings and PCJPB Communications/Signal Design Standards. The Contractor's alternate final design drawings shall be approved and stamped by a professional electrical engineer registered in California. The Engineer will render a decision concerning alternative design within 60 days of the Contractor submittal.

C. Submit marked-up Contract Drawings for approval, indicating any corrections or modifications to the final design that the Contractor may determine are required to conform to rules and regulations. Submit these revised drawings for the Engineer's approval within 60 days after Notice to Proceed.

D. Submit proposed plans, procedures, data sheets of proposed materials, application logic, installation details, shop drawings, mechanical drawings, proofs of compliance with applicable standards, and other pertinent data required to fully demonstrate the Contractor's proposed plan for the manufacture, installation, testing, and maintenance of the various signaling systems. Submit for Engineer's approval within 60 days after Notice to Proceed. Plans shall include:

1. Proposed plan for providing alternate methods of wayside signaling and highway crossing warning systems protection when signal components are relocated, deactivated, altered, or modified in order to accommodate construction work.

2. Plan for point protection and fouling when crossover or turnouts are installed or removed.

E. Signal system shop drawings and design submittals shall include any CADD files in AutoCAD formats. Signal circuit drawings shall conform to the PCJPB CADD standards. Submit electronic files on CD-ROM.

F. As part of the Site Specific Work Plan (SSWP) submission for review and approval by the Engineer, prepare and submit a detailed Signaling Construction Sequencing Plan for each location where a signal system is to be modified, installed, or removed. The Plan, as a minimum, shall contain a wire-by-wire for each wire to be disconnected and/or connected, and the following:
1. A narrative description of the work to be undertaken at the designated location.

2. A step-by-step sequence of work description which identifies those steps during which the existing system will be disabled, and a description of what steps will be taken to assure that the signal system will be tested and returned to full operation without causing a delay to any train movement.

3. An estimate of time to complete the critical steps in the sequence specified in step-by-step sequence of work description.

G. Submit circuit drawings indicating any required modifications to new systems or existing circuits where only a segment of the new work can be completed or the complete system must be placed in operation in phases. Submit these temporary interface drawings for the Engineer’s approval a minimum of 30 days prior to the scheduled cutover.

1. Revisions to existing circuit plans shall use the "Xs" and "Os" convention to show changes. Encircling the change with "Xs" shall identify deletions. Encircling the change with "Os" shall identify additions. The Contractor may, with the prior approval of the Engineer, alternately use the "Red In"/"Yellow Out" convention if Contractor provides seven colored copies of the drawing.

H. Request approval from the Engineer prior to making any deviation, modification, or changes to the approved design drawings. During the field testing/cut-over period, obtain the approval of the Engineer’s representative on site for any deviations, changes, or modification to the design drawings.

1.08 SUBMITTALS

A. Submit product information, references, shop drawings, and test data as detailed

1.09 DELIVERABLES

A. Submit manufacturers’ warranties, instruction sheets, and part lists supplied with materials to the Engineer prior to Final Acceptance.

B. Operation and Maintenance Manuals: Refer to Section 01730, Operations and Maintenance Manuals. A minimum of 30 days prior to placing any system in-service, submit to the Engineer 10 sets of application, installation, operating, and maintenance manuals of all new equipment and systems utilized under this Contract which are provided by the Contractor. Include complete material ordering reference numbers for each type of product.

1.10 QUALIFICATIONS AND DUTIES OF SIGNALING PERSONNEL

A. Refer to Section 01005, Contractor’s Personnel and Equipment. 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.

B. Signal Engineer as used herein shall be understood to mean Contractor’s railroad signal engineer or engineers approved by the Engineer. Signal Manager as used herein shall be understood to mean Contractor’s railroad signal manager or managers approved by the Engineer.

C. 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.

D. 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 major and critical activities, such as cutovers under the direct supervision of the Signal Engineer.

E. Signal Engineer shall direct and organize the performance of all tests on signaling equipment and systems, under direction of the Engineer, prior to releasing the systems for service. The Signal Engineer shall be responsible to ensure that all applicable test documentation other than that documentation provided by the Engineer, is completed prior to, or immediately after, in-service testing is completed.

F. 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 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, and PCJPB commuter trains. Candidate shall have a similar level of working experience to Caltrain system. The Engineer's decision concerning the candidate's qualifications will be final. Begin no signaling related work prior to obtaining Engineer's approval of the Signal Engineer. In addition, obtain the 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. Propose alternate personnel if the
original candidate is found unacceptable.

G. 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 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, and PCJPB
commuter trains. Candidates shall have a similar level of working experience to
Caltrain system. The Engineer's decision concerning the candidate's
qualifications will be final. Begin no signaling related work prior to obtaining the
Engineer's approval Signal Managers. Obtain approval of and provide additional
Signal Managers as required depending upon the level and type of work being
performed.

H. Propose alternate personnel if the original candidate is found unacceptable.
Previous qualification as a Signal Engineer or Manager on other PCJPB projects
does not constitute qualification as a Signal Engineer or Manager for this
Contract.

I. The 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 Engineer and is not subject to protest or appeal.

J. All Contractor field personnel shall receive safety training in accordance with
Section 01005, Contractor's Personnel and Equipment, and 01545, Work Site
Safety and Security.

1.11 AS-BUILT DOCUMENTATION

A. Refer to Section 01720, Contract Record Documents, for requirements
preparation and submittal of Record Documents.

B. The following as-built documentation requirements augment requirements
specified in Section 01720, Contract Record Documents. After a location is
placed in service, submit as-built documentation as follows:

1. Detailed circuit drawings within 3 working days.

2. Submit four copies of as-built corrections to the Engineer within 3
working days.

3. Civil Drawings which show the physical location of all signal apparatus
and conduits, both along the tracks and perpendicular to it, and heights
of all signal structures within 60 calendar days.
C. Annotate the as-built drawing sets to show all approved circuiting and wiring changes made during installation and testing of the location prior to placing it in service, and any approved changes made after placement in service. Clearly identify all changes on the drawings using the "Red In"/"Yellow Out" convention. Changes shall be dated and initialed by the Contractor's responsible Signal Engineer. Identify the date that the location was tested and placed in service in the revision block of the drawings.

D. In addition to the as-built drawings provided to the Engineer, one set shall be bound and shall be kept in the instrument enclosure at a location and manner approved by the Engineer. As-built drawings shall be clean and legible. The as-built drawings shall not be removed from the field location after the location is placed in service without the prior written approval of the Engineer.

E. The final as-built drawings shall be 11 inches by 17 inches, unless authorized by the Engineer to substitute another size.

F. Each circuit that continues on another drawing shall be annotated with drawing number and routing information for the continuation of the circuit.

G. The circuit drawings shall show all individual circuits. Typical circuits will not be accepted.

H. The location plans shall show all cable installed with the number of conductors, the size of conductors, the type of cable, termination points of conductors, and the circuit on each conductor. Separate cable plans shall be drawn if cable information cannot be shown in a neat and organized manner on the location plans.

I. The shop drawings shall be detailed equipment drawings for each type of equipment installed.

1.12 TRACK AVAILABILITY REQUIREMENTS

A. General: Refer to Sections 01011, Work Planning, and 01040, Work Hours and Track Access, for track access and related provisions. PCJPB Commute Service and any freight service may not be interrupted by the Work of this Contract, except as provided in the Contract Documents.

B. Signal Cutovers may be required under traffic.

C. Signal Cutovers under traffic will require coordination between the Contractor, PCJPB, other railroad, as applicable, and the Operator of Record to keep train delays to a minimum.

1.13 SCHEDULE OF VALUES

A. Submit the Schedule of Values for signal bid items as required under General Provisions GP9.2, Schedule of Values, and in accordance with the following additional requirements:
1. Schedule of Values for the signal bid items shall include all interface circuits and staging necessary to place the location in service at each stage, all acceptance testing and transportation of materials, all equipment rental, and all pretesting and removal of old equipment.

2. Organize Schedule of Values for signal bid items to assign a value to each signal location. A location is defined as a grade crossing warning system, an intermediate signal location, or a Control Point.

1.14 WARRANTY

A. Provide warranties for all equipment and material covering parts and labor for two years from the date equipment or material is "placed in service".

PART 2 – PRODUCTS

2.01 EQUIPMENT – GENERAL

A. Signaling materials and equipment shall be the products of manufacturers regularly engaged in the production of such material and equipment and shall be the manufacturer's latest design. The materials and equipment shall have shown proven performance in the US or Canada for a minimum of 5 years. Materials and equipment shall be delivered to the job-site in unbroken packages, reels, or other forms of containers.

B. All materials and equipment shall conform to the recommendations of AREMA C&S Manual, except as modified in the Specifications and Contract Drawings.

C. Reference to specific equipment and manufacturers is intended to establish quality, overall design, and fit, subject to compliance with all criteria specifications. Equipment equal to or exceeding the specifications and requirements may be used subject to the Engineer's written approval. Should alternate equipment be accepted, the Contractor shall perform all necessary work to fit the alternate equipment to these specifications and to revise the Contract Drawings at no additional cost to the PCJPB.

2.02 ELECTRICAL AND ELECTRONIC COMPONENTS

A. Design and construct fusing of all dc power supplies and circuitry according to the following requirements:

1. Circuit breakers and fuses shall be the correct side-band rating for circuit current interruption and shall protect the electrical equipment and circuits from short-term and long-term overloads.

2. Fuses shall be sized to protect the wire

3. Fuses shall be in the positive leg of the power supply

4. Fuses shall be of the nonrenewable indicating type
5. All branch feeds for a circuit shall be from the same fuse to prevent fuse cascading due to branch fusing carrying loads for other circuits.

6. Fuses shall be no smaller than 5 amperes unless otherwise shown on the Drawings.

7. Loads shall be divided so that no normal operating current is more than 75 percent of the fuse rating.

8. Fusing shall be functionally oriented to minimize the equipment affected by a blown fuse (i.e., per track, switch control circuits, etc.)

9. Fuse clips shall be constructed to retain their resilience under all installation and service conditions and to ensure a positive contact between the clips and the fuse.

B. Printed Circuit (PC) Cards and Connectors:

1. The PC cards shall be mounted in 19-inch card files unless otherwise approved by the Engineer.

2. The PC wiring shall be organized so that wires serving the same function shall be connected to the same terminal of PC cards. PC cards containing the same circuitry and programming, where applicable, shall be interchangeable between subsystems.

3. The design and construction of PC cards of the same subsystems shall be the same. Cards of different subsystems shall be of the same design and construction wherever practicable.

4. PC cards shall be of glass epoxy construction. Card material shall meet the requirements of NEMA, Type FR-4. Cards shall have sufficient thickness to permit easy insertion and removal, and shall be physically keyed to protect against incorrect interchange. Circuits shall be formed by etching. Conductor material shall be copper and shall be protected from exposure to air.

5. PC cards containing components that may be damaged if a plug connector or plug-in unit is removed while the equipment is energized shall be clearly identified in the equipment maintenance manual. PC cards shall be marked or labeled with a warning note on the individual board, be conspicuously located on the module, or by an alternate means as approved by the Engineer. A means shall be provided to remove power from the module or card file.

6. Components mounted on the PC card, weighing more than 1/2 ounce or with a displacement of more than 1/2 cubic inch, shall have a mechanical supporting attachment to the card separate from all electrical connections.
7. Do no stacking or piggybacking of PC sections in order to accomplish changes or modifications to wiring or components on printed circuit cards.

8. Connectors shall have plating with a minimum thickness of 0.00005 inch.

C. Printed Circuit Card Files:

1. There shall be not more than one type of card file for each size of PC card. The card file plug boards shall be registered to agree with the registry of the associated PC card. PC cards shall not project beyond the front of the equipment rack when mounted in the card file.

2. Card files shall be installed in dust-proof cabinets and protected with dust covers.

3. Insulated cable clamping devices shall be located on the back of the file in such a way that wires terminating in the files shall be installed in a neat and secure bundle, rigidly supported, and protected to prevent chafing of insulation. Cabling provision on the file shall permit wires to enter or leave the file from both the right and left sides. Such cabling shall not restrict access to the card file when the rear covers of the card files are removed.

2.03 SHOP FINISHES

A. Factory finish signal equipment with the exception of signal system parts which are stipulated as field finished in AREMA C&S Manual, Part 1.5.10, and aluminum alloy and galvanized metal components. If manufacturer typically provides factory painted finish for aluminum alloy and galvanized components, include such information in equipment submittals for Engineer’s acceptance.

B. Finishes shall comply with AREMA C&S Manual, Part 1.5.10, signal equipment manufacturer’s standards, and provisions specified herein. It shall be understood that where AREMA C&S Manual, Part 1.5.10, uses the word “should” that the word “shall” shall be substituted except as accepted by the Engineer in writing.

1. Finish terminal boards and interior of shelters with white gloss fire retardant paint.

2. Factory finish signal equipment with aluminum paint except as otherwise specified herein and in AREMA C&S Manual.

3. For signal system parts which AREMA C&S Manual stipulates as shop primed and field finish, shop prime in accordance with requirements specified in Section 05200, Structural Steel.

4. For signal system parts which AREMA C&S Manual stipulates to receive shop prime and finish coats followed by field finish coat, coordinate shop finish coat with field finish specified in Section 09900, Paints and Coatings.
2.04 FIELD PAINT MATERIALS

A. Field finish as specified in Section 09900, Paints and Coatings, and AREMA C&S Manual, Part 1.5.10. Exterior surfaces shall receive heavy duty finish system.

B. Touch-up Paint for Signal Manufacturer Finishes: Touch-up paints recommended by signal manufacturer, including aluminum touch-up paint.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Contractor shall make all necessary modifications to the existing signal system, protect or relocate existing cabling, signals, switches, and signal shelters; and modify associated signal and highway grade crossing systems to ensure the existing signal system operates as intended during construction and installation of the new signal system. Protect operating signal and highway grade crossing systems to ensure train operations are not interrupted and safety is maintained.

B. Contractor shall take no action which will violate any rule or regulation as specified by CFR 49, the General Code of Operating Rules, timetable instructions, general order, bulletin, or special instruction; which will reduce the integrity of the signal system; or endanger railroad personnel, the public, or employees.

C. All equipment installation as described herein or as shown in the Contract Drawings shall be in accordance with the Caltrain Standards.

D. Ensure that equipment within the instrument shelters and relay cases is securely anchored or otherwise fastened in enclosure upon completion of enclosure installation. Securing equipment shall not negate the requirements to maintain isolation between ground systems as otherwise called for in these Specifications.

E. An updated, detailed set of the approved signal design drawings shall be kept at the each field location for equipment as it is placed in-service.

3.02 FIELD FINISHES AND TOUCH UP

A. For signal system parts which AREMA C&S Manual, Part 1.5.10, stipulates as shop primed and field painted, field finish as specified in Section 09900, Paints and Coatings, and AREMA C&S Manual, Part 1.5.10, including requirement to apply one field coat prior to field assembly and one field coat following field assembly.

B. Touch-up signal manufacturer’s finishes after installation.

END OF SECTION
SECTION 18050
COORDINATION WITH PCJPB PROCUREMENT CONTRACTOR

PART 1 - GENERAL

1.01 DESCRIPTION

A. Section includes requirements coordinating installation, inspection, and testing as well as receiving of new Owner-furnished material or equipment with the Engineer and with the Owner’s vendor or supplier. Notify the Engineer in writing a minimum of 30 days prior to any installation, inspection and testing of such material or equipment.

B. Refer to Section 01600, Materials, in the paragraph "Acceptance of Owner-Furnished Materials".

1.02 SUBMITTALS

A. Submit Acceptance Test Procedure documentation on all Owner-furnished equipment prior to transport of the equipment.

1.03 WARRANTY

A. Because the manufacturer’s warranty for Owner-furnished material begins upon transfer of custody of the material, supplement the manufacturer’s warranty for the amount of time elapsed between acceptance of the material and final cutover and as required under General Provisions GP4.6, Guaranty of Work. The supplemental warranty shall include all costs to repair or replace material which is damaged while in Contractor’s care or fails prematurely and as required under General Provisions GP4.6, Guaranty of Work. Make arrangements for and pay costs of such repairs performed by and replacements provided from the original equipment manufacturer.

PART 2 – PRODUCTS

2.01 SOURCE QUALITY CONTROL

A. Test all Owner-furnished equipment before transporting it to the job site. Conduct this acceptance testing for all equipment in accordance with the Contractor's Acceptance Test Procedure. Prior to transportation, submit a copy of the documentation of acceptance testing to the Engineer.

PART 3 - EXECUTION

Not Used.

END OF SECTION
SECTION 18100
INTERLOCKING CONTROL

PART 1 - GENERAL

1.01 DESCRIPTION
A. Section includes requirements for installing, testing, and documenting Owner-furnished pre-wired vital microprocessor based interlocking controller racks and local control panels that provide the functionality shown on the Contract Drawings.

B. Final application logic programs, including EPROMS will be furnished by the Owner.

1.02 REFERENCE STANDARDS
A. Code of Federal Regulations (CFR), Title 49, Transportation:
   1. Part 236 Rules, Standards, and Instructions for Railroad Signal System

B. American Railway Engineering and Maintenance of Way Association (AREMA):

1.03 SUBMITTALS
A. Submit a narrative explanation of the electrical and/or mechanical methods of configuration control used to ensure that the application logic software installed is the correct software for the specific location and that it is the latest version. It shall explain Contractor’s procedures for handling components of the vital interlocking controller.

B. Submit certified acceptance reports.

C. Submit test reports and verification of tests as described herein under Testing.

1.04 QUALITY ASSURANCE
A. Install and test the interlocking controller and local control panel (LCP) so as to conform to and provide all applicable requirements of CFR 49, Part 236, and the recommendations of AREMA C&S Manual Part 2.2.10. When following the recommendations of the AREMA C&S Manual substitute the word “shall” for the word “should” in the applicable Manual Part.
1.05 DELIVERY, STORAGE, AND HANDLING

A. Package plug in modules for shipment separately from their card cage units using ESD safe packaging. Protect each item from damage or loss during handling and shipment.

B. Clearly identify each controller unit, LCP, and their associated components on the packing crate, referencing its intended location.

1.06 WARRANTY

A. Provide warranty from defects arising from improper handling for 2 years from the first date of service.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Solid State Micro-Processor Interlocking Controller, software, and local control panels will be Owner-furnished.

2.02 FACTORY TESTING

A. Conduct an acceptance test on the unit prior to loading at the warehouse. Provide certified acceptance reports with each unit at time of delivery.

PART 3 - EXECUTION

3.01 PREPARATION

A. Ensure that test and specialized installation equipment recommended by the manufacturer to make any readings or adjustments is in the Contractor’s possession and within the project limits a minimum of 30 days prior to installation.

3.02 INSTALLATION

A. Wire and install the microprocessor-interlocking controller and the LCP in accordance with rack layout provided in the Contract Drawings.

B. Load all programmable and configurable modules with application software and perform any configuration necessary.

3.03 FIELD QUALITY CONTROL

A. Conduct all applicable tests as recommended in AREMA C&S Manual Parts 2.4.1 and 7.4.1 to ensure proper operation of the signal and grade crossing warning systems.

B. Conduct tests to ensure that the signal system conforms to CFR 49, Part 236.

C. Conduct all tests required under Section 18600, Signal Systems Testing.
D. Testing, including pre-testing, shall include operating all switch machines and lighting all signals. The use of lamp simulators in lieu of, or in parallel with, signal lamps will not be allowed in pre-testing. An exception may be authorized by the Engineer where a signal or switch machine is in service and will be reconfigured for final cutover or cannot be installed or wired until final cutover.

END OF SECTION
SECTION 18110
SOLID-STATE CODED TRACK CIRCUITS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Section includes requirements for furnishing, installing, testing, and documenting solid-state track circuit elements.

B. Final application logic programs will be furnished by the Owner.

1.02 REFERENCE STANDARDS

A. Code of Federal Regulations (CFR), Title 49, Transportation:
   1. Part 236 Rules, Standards, and Instructions for Railroad Signal System

B. American Railway Engineering and Maintenance of Way Association (AREMA):

1.03 SUBMITTALS

A. Submit a narrative explanation of the electrical and/or mechanical methods of configuration control used to ensure that the application logic software installed is the correct software for the specific location and that it is the latest version. It shall explain Contractor’s procedures for handling components of the solid-state track circuit equipment.

B. Submit certified acceptance reports.

C. Submit test reports and verification of tests as described herein under Testing.

1.04 QUALITY ASSURANCE

A. Install and test the solid-state track circuit equipment in accordance with all applicable requirements of CFR 49, Part 236 and the recommendations of the AREMA C&S Manual, Part 8.1.2. When following the recommendations of the AREMA C&S Manual substitute the word “shall” for the word “should” in the applicable Manual Part.

B. Perform operational testing of the equipment in accordance with the requirements specified in Section 18600, Signal Systems Testing.
1.05 DELIVERY, STORAGE, AND HANDLING

A. Ship the solid-state modules separately from the wired card cages. Package modules individually in ESD safe packaging, in a sturdy carton with the type of module printed on the outside of the carton.

B. Package plug-in modules for shipment separately from their card cage units using ESD safe packaging. Protect each item from damage or loss during handling and shipment.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Electronic track circuits shall be compatible with highway grade crossing constant warning devices. Utilization of bi-directional, unidirectional, and auxiliary crossing control functions shall be provided per Contract Drawings and manufacturer’s specifications. Track filters shall be installed in track leads, as shown on the Contract Drawings.

B. Where new equipment is to be furnished and installed in existing locations, the equipment furnished shall be the same make as called for in the Contract Documents.

C. Track circuit shall function to provide continuous train detection throughout the length of the circuit whenever a shunt of 0.06 ohms is applied to the rails, including the turnouts.

D. Furnish any specialized test or calibration instruments, equipment, or tools that may be needed in order to test and place in-service the equipment installed under this Section, as shown on the Contract Drawings. Ensure all test and diagnostic equipment is in the Contractor’s possession and within the project limits a minimum of 30 days prior to installation.

E. Conduct an acceptance test on Owner-furnished units prior to loading at the warehouse.

F. Conduct acceptance testing of Owner-furnished components before transporting from the warehouse and installing. Provide certified acceptance reports at time of delivery.

2.02 APPLICATION LOGIC

A. The Owner will provide the application logic for each programmable module to the Contractor. Application Logic will be furnished upon demonstration of readiness for pretest. This application logic will provide the functionality as shown in the Contract Drawings and shall conform to CFR 49, Part 236. Where specified in the Contract Documents, the Contractor shall furnish the program specified to the manufacturer for factory testing and certification.
PART 3 - EXECUTION

3.01 INSTALLATION

A. Install solid-state coded track circuits at locations indicated on the Contract Drawings.

B. Install the solid-state track circuit equipment in signal instrument shelters or cases as shown on Contract Drawings.

C. The solid-state track circuit equipment layouts shall provide for easy access to test points, indicators, and adjustments.

D. Install equipment in accordance with the manufacturer's installation and adjustment procedures.

3.02 TESTING

A. Conduct tests as recommended in AREMA C&S Manual Parts 2.4.1, 3.3.1, and 7.4.1 to ensure proper operation of the signal and grade crossing systems.

B. Conduct tests to ensure that the signal system conforms to CFR 49, Part 236.

C. Conduct all tests required under Section 18600, Signal Systems Testing.

D. Testing, including pre-testing, shall include operating any handthrow switches and lighting all signals. The use of lamp simulators in lieu of, or in parallel with signal lamps will not be allowed in pre-testing.

END OF SECTION
SECTION 18200
SIGNAL LAYOUTS, STRUCTURES AND FOUNDATIONS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Section shall include disassembling, relocating and installing existing or new signals.

B. Signal layouts, as specified herein, shall consist of foundations, signal heads, and all structures including ground-mounted masts, ladders, platforms, and all mounting hardware required to construct signals.

C. Contractor shall furnish and install signals and marker lights as shown on the Contract Drawings at existing and new signal locations.

1.02 REFERENCE STANDARDS

A. American Railway Engineering and Maintenance-of-Way Association (AREMA)


1.03 DESIGN REQUIREMENTS

A. Signal Foundation Structure: The Contractor is responsible for the foundation structure type selection and its design. The design of the signal foundation’s structure and stability shall be in accordance with the AREMA. Design calculations shall be prepared by a licensed California professional civil engineer with a minimum of 5 years experience in the design of similar foundation structures.

B. Signal aspect shall be distinct and unmistakable when viewed from a height of 7 to 12 feet above top of rail at a distance of 1,000 feet. Nominal sighting distance shall be 2,000 feet. Where unobstructed sighting distance for a standard signal arrangement is less than 2,000 feet, supply and install wide angle or spread lens and adjust the signal head for the maximum sighting range possible. Contractor shall provide the Engineer with written notification with any sighting problems and location of where spread or wide-angle lenses are installed.

1.04 SUBMITTALS

A. Submit shop drawings for each type of signal unit and each type of signal layout to be furnished by Contractor. Show all ladders, masts, bases, arms, and required mounting hardware. Show location and method of mounting the signals to the structure.

1. Provide necessary dimensions, hardware, method of mounting signal structures, and material specifications for all items to be furnished.
B. Submit shop drawings for each type structure foundation.

C. Submit Contractor’s Installation Procedure for approved. The procedure shall include a detailed description of installation activity and sufficient detail to allow the Engineer to determine the validity of the installation procedure.

D. Submit design calculations for the signal cantilever/bridge foundation.

1.05 QUALITY ASSURANCE

A. Signals, structures, and related hardware shall meet the recommendations of AREMA C&S Manual, Section 7, and applicable portions of Manual Part 3.2.5 where they do not conflict with any requirements specified herein

B. Inspect each signal layout after it has been installed in the field. This inspection shall conform to the Contractor’s Installation Procedure as accepted by the Engineer.

C. Foundations shall meet all recommendations of AREMA C&S Manual Parts 14.4.1.A through 14.4.36 inclusive, where requirements of the AREMA Specifications do not conflict with any requirements specified herein.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Ship signal lamps or LEDs separately from the signal in which they will be used.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Furnish colorlight or searchlight signals, as indicated in the Contract Documents, and marker light assemblies. Signals and marker light assemblies shall be in accordance with Caltrain Engineering Standards.

B. Furnish signal masts, signal cantilevers and signal bridges, as applicable, in accordance with Caltrain Engineering Standards.

C. Furnish mounting brackets for marker light assemblies, ladders, junction boxes, housings, backgrounds, hoods and any other nuts, bolts, and associated hardware.

D. Furnish foundations for signal masts, signal cantilevers, and signal bridges, as applicable, in accordance with Caltrain Engineering Standards.

2.02 SIGNALS

A. Signal mounting shall conform to the Caltrain Engineering Standards.

B. Signal lamps or LEDs shall be products specified in the Contract Documents or equal.
2.03 SIGNAL MASTS

A. Mast assemblies for ground mounting shall conform to the Contract Drawings and Caltrain Engineering Standards.

2.04 SIGNAL BRIDGES AND CANTILEVERS

A. Refer to the Contract Drawings for Signal Bridge and Cantilever requirements.

B. The junction box shall have two terminals with insulated test links, as specified in Section 18360, Signal Systems Miscellaneous Products, for each cable conductor. Provide 10 percent spare terminals. Do not overcrowd terminals.

C. Cable entry to the junction box shall be direct from the signal structure. External conduit construction is not acceptable. Provide an opening approximately four by six inches near the base of the signal structure under each junction box location to allow access for cable sealing at the foundation. Provide bolt-on access plate which will cover the opening under normal conditions.

D. Locate junction box either at the base of a main support mast or on a main support mast at a height of between 3 and 5 feet above the finished grade level at the base.

E. The method of routing cables from the junction box to each signal mounted on the structure shall be to route the cables within the tubular members of the structure to the greatest extent possible. Pull cables entirely through the structure members, mast, and signal mounting brackets, unless otherwise approved by the Engineer. To facilitate this, provide appropriate pull box locations as needed, located a maximum of 5 feet from each signal. Edges shall be smooth and rounded to accommodate cable installation. Provide a means to prevent entry of rodents and insects at the bases of the vertical masts without cable entrances.

1. Use galvanized rigid steel conduit where wire is to be run external to the structural members, except as noted.

2. Use flexible armored conduit to make the connection from the pull box to the individual signal heads.

2.05 SIGNAL FOUNDATIONS


B. Construct galvanized steel foundations of steel angle and plate welded together. Foundations shall be constructed of 2-1/2 inch by 2-1/2 inch by 1/4-inch steel angle and 1/4 inch steel plate.

C. Bolt spacing shall be to manufacturer’s standards for the equipment to be supported by the foundation.

D. Concrete Foundations: Cast-in-place in accordance with Section 03300, Cast-in-Place Concrete, or precast concrete as manufactured by Dixie Precast or equal.
PART 3 - EXECUTION

3.01 INSTALLATION - SIGNALS

A. Contractor shall install signal layouts in locations as indicated on the Contract Drawings and as shown on the accepted shop drawings. No part of any signal layout shall conflict with Caltrain Engineering Standards, Code of Federal Regulations, Part 49, or CPUC rules and regulations.

B. Locate signals centered between insulated joints, except where physically not possible. In such instances, Contractor shall submit a recommendation to the Engineer for approval.

C. Center line of signal mast shall be 12 feet 0 inches from centerline of track unless a deviation from this is approved by the Engineer, as shown on the Contract Drawings or required to meet CPUC clearance requirements.

D. Install signal units level and plumb on their foundations. Leveling nuts shall be used as shown on the Caltrain Engineering Standards.

E. Install signal layouts in accordance with the applicable recommendations of AREMA Signal Manual, Part 7.4.1 and Caltrain Engineering Standards.

F. Install platforms for each signal unit level.

G. Align signals for maximum viewing distance before placing in service.

H. Refer to Design Requirements herein regarding signal aspect and sighting distances. Install signals and verify sighting distances. Provide the Engineer with written notification with any sighting problems and location of where spread or wide-angle lenses are installed.

I. Mount signal heads on an offset arm as shown in Caltrain Engineering Standards. Signal heads shall also be able to swivel on the offset arm and be adjustable.

J. Signal nomenclature shall be as shown on the Contract Drawings.

K. The underground cable shall be dressed, potheaded, tagged, and terminated in the signal junction box as specified in Section 18360, Signal Systems Miscellaneous Products. The conductor size of the underground cables shall be at least as large as that shown in the Contract Drawings.

L. Wiring from the junction box base to the signal heads shall be minimum No. 10 AWG copper stranded wire or larger as shown on the Contract Drawings.

M. Install identification tags on each wire. These tags shall bear the nomenclature shown on the accepted Shop Drawings.

N. Install signal cantilevers as shown on Contract Drawings.
3.02 INSTALLATION - SIGNAL BRIDGES AND CANTILEVERS

A. Signal bridges and cantilevers shall be installed as shown on Contract Drawings.

3.03 INSTALLATION - FOUNDATIONS

A. Install each foundation in accordance with the approved Contractor’s Installation Procedure for each type of foundation, as herein specified, and as shown on the Contract Drawings. The absence of a specific task listing herein does not relieve the Contractor of the responsibility for providing a complete and functional installation.

B. Refer to Section 01047, Utilities and Systems Coordination, for requirements for locating and protecting existing utilities. Advise the Engineer immediately if any utility or cable interferes with the foundation work. After locating an interference, allow 72 hours for the Engineer to relocate or mitigate the interference.

C. Prior to placing steel foundations in the excavations, place and compact a crushed stone base in accordance with Section 02300, Earthwork.

D. When placing foundations, exercise care and ensure that anchor bolts are not bent or threads damaged. Protect anchor bolt threads, washers, and nuts by applying friction tape or other accepted method satisfactory to the Engineer, until the unit to be supported is installed.

E. After backfilling foundations, ensure that the foundation is plumb and level. Where galvanized steel foundations are installed, top of final grade shall be no more than 24 inches below top of foundation.

F. Install foundations to the lines, grades and dimensions required as determined by the Contractor and accepted by the Engineer. Mounting bolts shall be of sufficient length to accommodate use of leveling nuts between the base of the equipment to be supported and the top of the foundation.

G. Where marker lights are located on signals, install new signal foundations or adjust existing signal foundations so the top of the marker assembly is not more than distance above top of rail indicated in the Contract Documents.

3.04 PAINTING

A. Touch up any damaged painted finish.

3.05 FIELD TESTS

A. Make tests for proper operation and setting of lamp operating voltages in accordance with Section 18600, Signal Systems Testing.

END OF SECTION
PART 1 - GENERAL

1.01 DESCRIPTION

A. Section includes requirements for relays. Unless indicated as Owner Furnished in Section 01600, Materials, or as relocated on the Contract Drawings, relays shall be Contractor furnished.

1.02 REFERENCE STANDARDS

A. American Railway Engineering and Maintenance of Way Association (AREMA):


1.03 SUBMITTALS

A. Contractor shall provide acceptance testing and documentation for each relay when it is transported from the warehouse to the job site.

B. Complete Test Report Form provided by the Engineer for each vital relay installed under this Contract. Use typewritten characters to fill in all information requested on the form.

1.04 QUALITY ASSURANCE

A. Vital relays shall meet the recommendations of AREMA C&S Manual Part 6.2.1, where they do not conflict with any requirements specified herein. Vital Relays shall be of the type as designated in the PCJPB Standard Drawings.

B. Factory testing of each relay shall be the manufacturer's standard.

C. Before any relay is used, obtain the Engineer's written acceptance. Acceptance will be based on the test results and the proper completion of the Test Report Form.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Ship vital relays separately from the wired racks in which they are to be used. Package relays individually; each in a sturdy corrugated cardboard carton with the drawing number of the relay printed on the outside of the carton. Store relays in a protected area until tested and installed.
1.06 SPARE PARTS AND SPECIAL TOOLS

A. Refer to Section 01600, Materials, for details regarding packaging and delivery of spare parts and special tools.

B. Furnish spare relays in the quantities indicated on the Contract Drawings.

C. Furnish one test tool or relay wrench for each shelter where relays are installed.

D. Furnish 12 inserting/extracting tools for each type of contact requiring a special tool.

PART 2 – PRODUCTS

2.01 GENERAL

A. Relays shall be in dustproof enclosures, except a provision shall be made for ventilation where required for heat dissipation.

2.02 VITAL DC RELAYS

A. General:

1. Vital Relays shall be Alstom Type B, Invensys Rail Type "ST", or equal. Contractor shall use the specific relays shown on the Contract Drawings.

2. Vital dc relays, unless otherwise indicated on the Contract Drawings, shall be of the plug-in type and rack-mounted. Relays shall have a transparent dust cover made of a nonflammable composition that will not support combustion.

3. Vital Relays, with a nominal operating voltage of 10 to 16 volts, shall be capable of operating continuously without resultant damage, with a minimum voltage range of 7 to 21 volts inclusive, applied to their operating circuits.

4. Vital relays shall have a test terminal to allow convenient measurement of the coil voltage.

5. Design biased neutral vital relays so that gravity alone will prevent the armature from picking up if the permanent magnet is de-energized or if no current is applied to the coil, due to interruption of the normal magnetic circuit.

6. All front contacts shall be silver-to-metal carbon, meeting the recommendations of the AREMA C&S Manual Part 6.2.1.

7. When three dc vital relays, suppressed as specified herein, are connected in parallel and operated as a test load from normal working voltage, a vital relay front or back contact that breaks this load shall be capable of at least five million operations at this load without the contact resistance, measured with ten milliamp current, exceeding five ohms.
8. Arc suppression for vital relays shall be built into the relay or into its plugboard.

9. Equip vital plug-in relays, except vital time-element relays and special application relays, with front current testing facilities. Where shown on the Contract Drawings, provide facilities to enable the testing of voltage from the front of the relay, without having to remove the relay or remove adjacent relays.

10. Equip vital relays with a registration plate to prevent relays of the wrong style, contact arrangement, or operating characteristics, from being inserted into the plugboard.

2.03 IDENTIFICATION

A. Facilities shall be included for mounting an approved typed or printed relay nametag for each relay, either on the relay cover or on the relay cabinet front plate, as applicable. The nametag shall be easily replaceable, but shall not come off during normal service.

B. Identification shall be in accordance with Section 18360, Signal Systems Miscellaneous Products.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Ensure that the relay operating characteristics have not been altered due to damage during shipping procedures.

B. Ensure that all ac and dc power buses are open while installing relays. Do not reconnect buses until all relays have been installed.

C. Install and wire the relays as shown on the Contract Drawings.

D. Identify each relay with nametag.

3.02 FIELD QUALITY CONTROL

A. All dc vital relays shall be tested and inspected in accordance with AREMA C&S Manual Part 6.4.1.

B. Perform tests in accordance with Section 18600, Signal Systems Testing.

C. Record test measurements on Test Report Form provided by the Engineer.

END OF SECTION
SECTION 18310
SIGNAL SHELTERS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Section includes requirements for new factory-wired equipment shelters and relocating existing equipment shelters.

1.02 REFERENCE STANDARDS

A. Code of Federal Regulations (CFR), Title 49, Transportation:
   1. Part 234 Grade Crossing Signal System Safety
   2. Part 236 Rules, Standards, and Instructions for Railroad Signal System

B. American Railway Engineering and Maintenance of Way Association (AREMA):

1.03 SUBMITTALS

A. Submit proposed Installation Test Procedures.

B. Submit load calculations, indicating sizes of load center panel, voltage drops, and all other 240/120 Vac equipment.

C. Submit Contractor’s Inspection and Acceptance Procedure.

1.04 QUALITY ASSURANCE

A. The Contractor shall provide documentation of acceptance “in good condition” before removing and transporting existing shelters to the job site.

B. The Contractor shall provide documentation of Factory Acceptance Testing before transporting new shelters to the job site.

C. Each shelter and case will be inspected after they have been installed and the Contractor shall correct any deficiencies. This inspection will be conducted in conformance with the requirements of the Contractor’s accepted Inspection and Acceptance Procedure.
1.05 DELIVERY, STORAGE, AND HANDLING

A. Properly fasten and brace equipment shipped within shelters and cases to prevent damage during transit. Replace any equipment damaged during transit or prior to in-service operation at no cost to the Owner.

B. Package all vital relays, batteries, and electronic plug-in modules in separate containers for shipment and do not install until the shelter is set at its final location.

PART 2 – PRODUCTS

2.01 GENERAL

A. Furnish factory-wired equipment shelters or junction cases, as described herein and as shown on the Contract Drawings. These shelters shall be complete with all the equipment shown on the Contract Drawings. Wiring shall conform to NEMA Standard ICS-70, or National Electrical Code (NEC), and the recommendations of the AREMA C&S Manual, as applicable.

B. Equipment shelters shall be products manufactured by P.T.M.W., Invensys Rail, GETSGS, or equal.

C. Equipment shelters shall be the size and layout shown on the Contract Drawings.

D. Equipment shelters shall be rain-tight and dust-tight, National Electrical Manufacturers Association (NEMA) 3R, ventilated, and have hinged doors with three point latch and handle.

E. Equipment shelters shall be constructed of 12-gauge galvanneal steel for floors, walls, and doors. Roofs shall be no less than 14-gauge galvanneal steel with a minimum of 50 lb/ft\(^2\) loading.

F. The entire structure shall be powder coated on the outside with TGIC Polyester Powder (or equal polyester powder) with a nominal thickness of four mils, but no less than three mils at any point on the surface of the enclosure in accordance with AREMA C&S Manual Part 1.5.10. The exterior color shall be light gray.

G. The steel instrument enclosures shall be complete with moveable shelves, wire chase, and backboard.

H. The equipment shelters shall provide access to underground and aerial cable entrance behind the main terminal rack. The top and sides shall be lined with heat and cold insulating material and constructed to prevent sweating. Provide ventilation openings as required for the size of the shelter proposed. No ventilation opening shall be made in the roof of the shelter. Provide lift rings to facilitate the movement of the shelter.

I. Provide ventilation openings in each door. The exterior of the ventilation openings shall be hooded to minimize the entrance of precipitation. Equip the interior of ventilation opening with sliding plate to allow the adjustment of airflow and with a replaceable dust filter. The doors shall be hinged and gasketed so that they will
provide a dust proof and weatherproof seal. Provide doors with exterior and interior handles, (interior handles not required on cases) welded to a three point locking device to ensure that the door cannot be locked until it is in the fully closed position. Provide doors with a two-position retaining device to secure the door when open.

J. Door openings shall be 32 inches wide by 86 inches tall unless otherwise specified on the Contract Drawings.

K. Provide thermostatically controlled exhaust fans, operated from 120 Vac and fused separately, in each shelter, as shown on the Contract Drawings. The thermostat that activates the fan control shall be adjustable and operate in the range of 70 degrees to 130 degrees Fahrenheit. Locate fans relative to the fresh air inlets to draw air over the equipment and size to renew the air within the shelter every 3 minutes. Exhaust fans shall have removable dust filters. Dust filters shall be either replaceable or cleanable.

L. Hinges shall be separate castings, securely fastened to the shelter and door. The hinges shall be equipped with bronze hinge pins, shall be lubricated by the manufacturer before the case is shipped, and shall have grease fittings for later lubrication.

M. Furnish equipment shelters with interior lighting and duplex 120 Vac power receptacles. Equip shelters and cases with double tube fluorescent lights, minimum 40 watts each, as required to provide complete illumination for all passages and sides, and operated from a switch conveniently placed near each entrance door. Furnish convenience outlets as part of each switch.

N. Shelter lighting and receptacle loads shall be fed from a ground fault interrupt circuit breaker used exclusively for these loads. Signaling logic and signal appliance power loads shall be fed from separate circuit breakers. The signal logic power and signal appliance power shall be ungrounded. The Contractor shall size circuit breakers and wiring.

O. Furnish shelters complete with a 120/240 Vac power distribution panel, circuit protective devices, and all appurtenances necessary to supply the ac power required at each site.

2.02 EQUIPMENT MOUNTING

A. General:

1. Mount equipment as shown in the Contract Drawings.

2. Mount all equipment in such a manner that a seismic event within the parameters of Section 18000, General Signal Requirements, will not cause damage or excessive motion.

B. Relay Plugboards:

1. Design plugboards for insertion of removable type contacts. The method of attaching the wires to the removable contacts shall be solderless connections. Design plugboard so that the removable contact will have a
direct connection with the contact and coil prongs. The plugboards shall be in accordance with the applicable sections of AREMA C&S Manual, Part 6.2.1.

2. All wires shall be of sufficient length to permit them to be moved to any contact on the same relay.

3. Equip the plugboards for vital relays with a registration plate to prevent relays of the wrong type, contact arrangement, or operating characteristics from being inserted.

2.03 IDENTIFICATION

A. Stencil a white identification number at the top of the front and rear frames of each rack or panel.

B. There shall be an identifying nameplate for each relay, or other instrument mounted on the rack or panel.

C. Equip the back and front of the relay plugboards with a tag, as specified in Section 18360, Signal Systems Miscellaneous Products. This tag shall indicate the nomenclature of the relay.

D. Identify terminals and both ends of all wires with a wraparound tag printed with the circuit nomenclatures and terminal designations as shown on the Contract Drawings and as specified in Section 18360, Signal Systems Miscellaneous Products.

E. Wire and cable conductor identification tags for terminal board mounting shall be as specified in Section 18360, Signal Systems Miscellaneous Products.

2.04 CABLE ENTRANCE TERMINAL BOARDS

A. Cable Entrance Terminal Boards shall be 3/4-inch Type AB exterior (five ply) plywood, mounted on a rack and painted with a fire retarding paint.

B. Cable Entrance Terminal Boards shall be located as shown on the Contract Drawings.

C. Multiple-unit terminal blocks for wire and cable conductors shall be in accordance with AREMA C&S Drawing 14.1.6. Furnish each binding post with two binding nuts, one clamp nut, and three washers.

D. Provide Invensys Rail or equal test links on all terminal pairs where conductors enter shelters.

E. Equip binding posts and exposed terminals of other apparatus for circuits exceeding 50 volts or greater (ac or dc) with insulating nuts and sleeves.

F. Cable entrance facilities shall be located as shown on the Contract Drawings.

G. Lightning arresters shall be as specified in Section 18360, Signal Systems Miscellaneous Products.
2.05 CABLE ENTRANCE PIPES

A. Cable entrance pipes shall be supplied by Contractor as specified in Section 18360, Signal Systems Miscellaneous Products.

2.06 GROUNDING

A. Shelter shall be fitted with four 36-inch long No. 2 ground wires cadwelded to exterior of the shelter at each corner. Cadwelding shall take place prior to powder coating the structure.

B. Grounding material shall be supplied by Contractor and installed as specified in Section 18450, Grounding.

2.07 INTERNAL WIRING

A. Internal wiring shall be in accordance with Section 18370, Signal Wire and Cable.

B. Minimum wire conductor sizes shall be as shown on the Contract Drawings unless otherwise approved by the Engineer.

C. Adhering to minimum wire size specifications does not relieve the Contractor’s responsibility of using wire sized large enough to safely and effectively provide power to the circuit it serves.

D. Solderless terminals, for stranded wire, shall be in accordance with Section 18360, Signal Systems Miscellaneous Products.

E. Solid terminal connectors shall be used for all short terminal jumpers.

F. Wire shall conform to the requirements in Section 18370, Signal Wire and Cable.

2.08 PAINTING - INSULATION

A. All instrument enclosures shall be furnished complete with a layer of rigid insulation on the walls, doors, and ceiling. Instrument shelters shall have a minimum 2-inch thick layer of rigid closed cell foam insulation rated R13. Instrument cases shall have a minimum 1/2-inch thick layer of rigid closed cell foam insulation rated R3.3. Insulation shall be suitable for residential installation.

B. The interior including the ceiling, walls, terminal boards, and shelves shall be finished with a primer and two coats of white latex enamel paint.

C. All paint shall be fire-retarding type.

D. Contractor shall apply typical legend for control point shelters, highway grade crossing shelters and cases as indicated on Caltrain Standard Drawings (SD-5000 series). Contractor shall consult with manufacturer of shelter prior to paint application.
2.09 EQUIPMENT RACKS
A. Equipment racks shall be the manufacturer's standard for the type of equipment furnished and shall be sized in conformance to the Contract Drawings.
B. Equipment racks shall include all necessary supports for wire and equipment.
C. Secure equipment racks by bolts attached to a threaded mounting plate structurally secured to the floor of the shelter. Attach stabilizing straps to the top of the racks as needed. Racks and mounting shall be secure enough to withstand a seismic event as specified in Section 18000, General Signal Requirements.

2.10 OTHER EQUIPMENT
A. Wiring Raceway (Wire Routing): Internal case wiring shall be contained within surface-mounted plastic raceway. Raceway shall be of a polycarbonate, low smoke type with a solid snap-on cover and flexible sidewalls. The sidewalls shall be of "finger" type construction allowing for insertion and removal of wire runs with terminations attached. The manufacturer shall determine sizes. Fill capacity shall not exceed 60 percent.
B. Panel Board: Furnish a single-phase, three-wire 120/240 VAC, 60 Hz panel board for each shelter furnished under this Contract. Size panel board as shown on the Contract Drawings. The capacity rating shall be in accordance with the Contractor's load calculations and the Contract Drawings.
C. Service meters shall conform to local codes.

2.11 GALVANIZED SHELTER FOUNDATIONS
A. All shelters shall be equipped with telescoping foundations complete with galvanized bolts, washers, nuts, and associated hardware. Galvanizing shall conform to Section 18360, Signal Systems Miscellaneous Products, and AREMA C&S Manual, Part 15.3.1.
B. Galvanized steel foundations for cases shall be constructed of steel angle and plate welded together. Foundations shall be constructed of 2-1/2 inch by 2-1/2 inch by 1/4-inch steel angle and 1/4-inch steel plate.
C. Bolt spacing shall be to manufacturer's standards for the equipment to be supported by the foundation.

PART 3 - EXECUTION
3.01 INSTALLATION
A. Mount shelters and cases level and plumb and secure thereon with the hardware provided. Do not use shims, spacers, or other filler devices to level and plumb shelters or cases.
B. Install cable entrance pipes through the cable knockout holes provided in the floor of the shelter behind the terminal board(s) as shown on Contract Drawings. Fill pipes
with a substance designed for the purpose that prevents entrance of debris, rodents, and other pests.

C. Ground shelters as specified in Section 18450, Signal Grounding.

D. Locate shelter as indicated on the Contract Drawings. If conditions do not allow placement as shown on the Contract Drawings, submit alternate placement for Engineer's approval.

E. Install relays on the relay plugboards corresponding to the relay nomenclature and identification plate, and securely fasten in place with the hardware provided by the relay manufacturer.

F. Place batteries on rubber matting on the floor of the house or bottom shelf of the case. Coat battery posts with approved grease and securely fasten battery connectors to the battery posts. Strap batteries or otherwise secure using a method approved by the manufacturer so that they will not tip or move in the event of an earthquake.

G. Mark each grade crossing warning device case or shelter with the street name, milepost location, emergency response number, and DOT inventory number per PCJPB Standards.

H. Install pullboxes and conduits. Provide slotted pullbox covers to accommodate the cable chute at new house locations. Place the house so the chute aligns with the slotted cover.

I. Make any modifications to the cable chute required to fit the pullbox and accommodate the cable installation. If it is necessary to cut the cable chute, ensure no rough edges, sharp edges, burrs, or other surfaces exist which have the potential to injure the cable.

J. Install foundations, including telescoping foundations, for shelters including Owner-furnished shelters.

3.02 AC POWER

A. Wall mount load center as shown on the Contract Drawings. Mounting height from floor, wire terminations, and clearances shall be in accordance with the NEC.

B. Install service meters as described in Section 18500, Service Meters.

3.03 FIELD QUALITY CONTROL

A. Test the functioning of the equipment contained within the instrument shelter in accordance with the requirements of Section 18600, Signal Systems Testing, CFR Title 49, Parts 234 and 236, and the recommendations of AREMA C&S Manual Part 2.4.1.
SECTION 18320
POWER SWITCH AND LOCK MOVEMENT

PART 1 - GENERAL

1.01 DESCRIPTION

A. Section includes requirements for dual control switch and lock movement, including switch target, for each interlocked track switch at new switch locations as shown on the Drawings. In addition, relocate existing switch machines where indicated on the Contract Drawings.

B. Refer to Division 19, Trackwork, for track construction requirements.

1.02 REFERENCE STANDARDS

A. American Railway Engineering and Maintenance of Way Association (AREMA):


1.03 SUBMITTALS

A. Submit installation drawings showing the tie straps and the mounting details of the switch and lock movement, including the connections to the track switch points and target.

B. Submit Acceptance Test documentation on switch and lock movement prior to shipment of the movements.

C. Submit copies of all field test reports.

1.04 QUALITY ASSURANCE

A. Switch and lock movements shall meet the recommendations of AREMA C&S Manual Part 12.2.1 for dual control high voltage applications, where they do not conflict with any requirements specified herein.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Protect switch and lock movements and their component layout parts against damage during handling and shipment.

B. During storage, properly lubricate and maintain switch and lock movement layouts on a regular timed program.
PART 2 – PRODUCTS

2.01 MATERIALS

A. Furnish complete dual control Electric Switch and Lock Movement Layouts, including switch targets.

B. Contractor-furnished Junction Box shall be RSE 6K1 Model N349656 manufactured by Ansaldo STS USA or Engineer approved equal.

C. Furnish Insulated Vertical No. 1 Rod with Basket.

D. Miscellaneous Fittings: Furnish all connectors such as threaded nipples, cable clamps, and electrical fittings as required for each switch and lock movement layout including 18-inch-long, 2-inch-diameter flexible conduit and connectors from movement to junction box.

2.02 SECURITY

A. Padlocks will be Owner-furnished.

2.03 SOURCE QUALITY CONTROL

A. Test each switch and lock movement before shipping it to the job site. Conduct this acceptance testing in accordance with the Contractor’s Acceptance Test Procedure for switch and lock movements. Submit a copy of the Contractor’s documentation of acceptance testing to the Engineer prior to shipping.

PART 3 - EXECUTION

3.01 GENERAL

A. Mount and adjust the complete switch and lock movement layout as specified herein and as indicated on the Contract Drawings.

B. Wire control and indication circuits for power-operated switches as shown on the Contract Drawings.

3.02 INSTALLATION

A. Prior to installation, coat all parts of the switch and lock movement that are not painted, or made of non-corroding material with an approved grease to prevent corrosion. Suitably plug or cap unused threaded outlets.

B. Where existing concrete ties are not used, install two 14 foot long timber ties for mounting the switch mechanisms where shown on the Contract Drawings. If a helper assembly is required, one of the switch mounting ties shall be 16 foot long.

C. Prior to mounting the switch mechanism on either concrete or timber ties, align the switch headblock ties at right angles to the straight stock rail, and space the
ties in accordance with the switch shop drawings, and condition the switch points to move without binding.

D. Install the switch and lock movements at the locations shown on the Contract Drawings.

1. Secure switch and lock movement to the switch ties using eight 7/8-inch bolts.

E. Remove any ballast necessary for the installation of each switch and lock movement layout and replace and tamp ballast after the installation has been completed. Spread excess ballast evenly between ties in the vicinity of the switch and lock movement layout. Remove ballast from between ties to allow unrestricted movement of switch rods.

F. Make a preliminary adjustment of switch and lock layout at the time of installation and a final adjustment when placing it in service, which shall result in the adjusting nuts being centered on the threads plus or minus 30 percent of the thread length. Make final adjustment at the time of the functional test. Make final adjustments in conformance with the recommendations of AREMA C&S Manual Parts 12.2.1 and 2.4.1, and the PCJPB Test and Maintenance Manual Chapter 2.

G. Do not apply power to the motor until the switch machine has been fully lubricated, thrown, and adjusted in hand throw. There shall be no rubbing or binding of switch rods or points on gauge plates, rails or ties. Follow manufacturer's adjustment and installation procedure.

H. During storage and after installation, properly lubricate and maintain switch and lock movement layouts on a regular timed program until accepted by the Engineer.

I. Exercise care and ensure that the switches, including switch tie plates, are thoroughly lubricated at all lubricating points, that all machined surfaces susceptible to rusting, both external and internal, are thoroughly coated with grease, as acceptable to the Engineer, and that threaded portions of switch rods and nuts are similarly coated and protected.

J. Lubricate the switch tie plates with graphite lubricant, as acceptable to the Engineer. Thoroughly steam clean the plates to remove all oil or grease prior to application of the graphite. Periodically renew the protective coating until such time as the Owner assumes responsibility for maintenance of the equipment.

3.03 SECURITY

A. Install Owner-furnished switch padlocks on trainman's access side of electric locks, and power and hand-throw levers of switch and lock movements.

3.04 TOUCH-UP

A. Touch-up the finish of equipment described in this Section in accordance with the AREMA C&S Manual, Part 1.5.10. Color shall match factory finish.
3.05 FIELD QUALITY CONTROL

A. Inspect each switch and lock movement after it has been installed and correct any deficiencies noted. Conduct this inspection in conformance with the requirements of the Contractor's Installation Inspection Procedure as accepted by the Engineer.

B. Conduct final operational tests of switch and lock movements as described in Section 18600, Signal Systems Testing.

END OF SECTION
SECTION 18330
SWITCH CIRCUIT CONTROLLER

PART 1 - GENERAL

1.01 DESCRIPTION
A. Section includes requirements for switch circuit controllers.

1.02 GENERAL
A. Switch circuit controller layouts shall include the controller unit, junction box, point lug, detector rod, shims, all required bolts, nuts, washers, pins, grease fittings, cotter keys, plates, adjusting brackets, and all hardware to mechanically couple the switch circuit controller to the track switch points and mount it on the ties.

B. Refer to Division 19, Trackwork, for track construction requirements.

1.03 REFERENCE STANDARDS
A. American Railway Engineering and Maintenance of Way Association (AREMA):

1.04 SUBMITTALS
A. Submit installation drawings showing the tie straps and the mounting details of the switch circuit controller, including the connections to the track switch points.

B. Submit Contractors Acceptance Test Documentation on switch circuit controllers prior to transport.

C. Submit copies of all field-test reports.

1.05 QUALITY ASSURANCE
A. Switch circuit controllers shall meet the recommendations of AREMA C&S Manual, Part 12.1.1, for a four front/back contact configuration where they do not conflict with any requirements specified herein. Mounting details shall conform to the Caltrain Design Standards.

1.06 DELIVERY, STORAGE, AND HANDLING
A. Protect switch circuit controllers and their component layout parts against damage during handling and shipment.

B. During storage, properly lubricate and maintain switch circuit controller layouts on a regular timed program.
PART 2 – PRODUCTS

2.01 MATERIALS

A. Furnish Electric Switch Circuit Controller Layout complete with rod, lug, and associated hardware.

B. Contractor furnished Switch Circuit Controllers and layouts, if required, shall be: Model 7J as manufactured by Alstom Signaling, Model U-5 as manufactured by Union Switch and Signal (now Ansaldo), or Engineer approved equal, complete with rod, lug and associated hardware.

C. Contractor furnished Junction Box shall be Model 091 428-ABX manufactured by Safetran Systems (now Invensys) or Engineer approved equal.

D. Furnish Insulated Vertical No. 1 Rod with Basket.

E. Miscellaneous Fittings: Furnish all connectors such as threaded nipples, cable clamps, and electrical fittings as required for each switch and lock movement layout including 18-inch-long, two-inch-diameter flexible conduit and connectors from movement to junction box.

2.02 GENERAL

A. Stranded wire: Furnish insulated No. 10 AWG stranded wire between the pedestal-mounted junction box and the switch circuit controller. Insulated wire shall be in accordance with Section 18370, Signal Wire and Cable.

B. Miscellaneous Fittings: Furnish all connectors such as threaded nipples, cable clamps, and electrical fittings as required for each switch circuit controller layout.

2.03 SECURITY

A. Padlocks will be Owner-furnished.

2.04 SOURCE QUALITY CONTROL

A. Test each switch circuit controller before transporting it to the job site. Conduct this acceptance testing in accordance with the Contractor’s Acceptance Test Procedure for switch circuit controllers.

PART 3 - EXECUTION

3.01 GENERAL

A. Mount and adjust the complete switch circuit controller layout as specified herein and as indicated on the Contract Drawings.

B. Circuits for switch circuit controllers shall be as shown on the Contract Drawings.
3.02 INSTALLATION

A. Prior to installation, coat all parts of the switch circuit controller that are not painted or made of non-corroding material with an approved grease to prevent corrosion. Suitably plug or cap unused threaded outlets.

B. Install one 10-foot long timber tie or concrete tie for mounting the controllers as shown on the Contract Drawings.

C. Mount controllers on new and existing timber or concrete ties in conformance to Caltrain Design Standards.

D. Dap and drill timber ties to meet the requirements of these Specifications. Limit of cutting or dapping shall not exceed 2 inches.

E. Secure the switch circuit controller to the switch ties, by 3/4 inch by 10 1/2 inch bolts.

F. Remove any ballast necessary for the installation of each hand throw switch layout and replace and tamp the ballast after the installation has been completed. Spread excess ballast evenly between ties in the vicinity of the switch and lock movement layout.

G. Make a preliminary adjustment of the controller layout at the time of installation and a final adjustment when placing it in service, which shall result in the adjusting nuts being centered on the threads plus or minus 30 percent of the thread length. Make final adjustment at the time of the functional test. Make final adjustments in conformance with the requirements of AREMA C&S Manual, Parts 12.1.1 and 2.4.1.

H. Underground cable terminating in the controller junction box shall be dressed and potheaded as specified in Section 18370, Signal Wire and Cable. Fan the individual conductors in a neat workmanlike manner, properly tagged and terminated. Wiring between switch junction box and switch circuit controller shall be No. 10 AWG insulated stranded flex wire. These wires shall also be tagged and terminated. Install the wires between the controller junction box and the controller mechanism in an approved flexible conduit with a minimum length of 10 inches and a maximum length of 21 inches. Fasten this flexible conduit to the switch junction box and switch mechanism with appropriate connectors.

I. After installation, properly lubricate and maintain switch circuit controller layouts on a regular timed program until accepted by the Engineer.

J. Exercise care and ensure that the controllers, including switch tie plates, are thoroughly lubricated at all lubricating points, that all machined surfaces susceptible to rusting, both external and internal, are thoroughly coated with grease, as acceptable to the Engineer, and that threaded portions of switch rods and nuts are similarly coated and protected.

K. Lubricate the switch tie plates with graphite lubricant, as acceptable to the Engineer. Thoroughly steam cleaned the plates to remove all oil or grease prior
to application of the graphite. Periodically renew the protective coating until such time as the Owner assumes responsibility for maintenance of the equipment.

L. Connect switch circuit controller rods to the normally closed switch point.

**3.03 SECURITY**

A. Install Owner-furnished switch padlocks on trainman's access side of electric locks and hand-throw levers of switch and lock movements.

**3.04 TOUCH-UP**

A. Touch-up the finish of all equipment described in this Section in accordance with the AREMA C&S Manual, Part 1.5.10. Touch-up shall match factory finish.

**3.05 FIELD QUALITY CONTROL**

A. Inspect each switch circuit controller after it has been installed and correct any deficiencies noted. Conduct this inspection in conformance with the requirements of the Contractor's Installation Inspection Procedure as accepted by the Engineer.

B. Conduct final operational tests of switch circuit controllers as described in Section 18600, Signal Systems Testing.

C. Test all functions of each switch and lock movement layout in accordance with Section 18600, Signal Systems Testing.

**END OF SECTION**
SECTION 18340
ELECTRIC SWITCH LOCK LAYOUTS

PART 1 - GENERAL

1.01 DESCRIPTION
A. Section includes requirements for Electric Switch Lock layouts.

1.02 GENERAL
A. Refer to Division 19, Trackwork, for track construction requirements.

1.03 REFERENCE STANDARDS
A. American Railway Engineering and Maintenance of Way Association (AREMA):

1.04 SUBMITTALS
A. Submit installation drawings showing the tie straps and the mounting details of the switch circuit controller, including the connections to the track switch points.
B. Submit copies of all field-test reports.

1.05 DELIVERY, STORAGE, AND HANDLING
A. Prior to installation, coat all parts of the Electric Switch Lock layout that are not painted or made of non-corroding material with an approved grease to prevent corrosion. Suitably plug or cap unused threaded outlets.
B. During storage, lubricate and maintain Electric Switch Lock and switch circuit controller layouts on a regular time program until installation. The Engineer shall have the right to monitor the Contractor's compliance with this maintenance required from time to time.

PART 2 – PRODUCTS

2.01 MATERIALS
A. Furnish new Low Style Electric Lock Operating Mechanisms and layouts, such as G & B Specialties Model 854 or Alstom Model 10A.
B. Furnish new High Style Electric Lock Operating Mechanisms and layouts, such as Alstom Model 9B or United Switch and Signal (now Ansaldo) US&S Model SL6A.
C. Rods and Hardware. Each Low Style Electric Switch Lock shall securely lock the switch hand throw lever in the normal position only. Provide a single color LED with
the assembly to indicate switch lock release. Each High Style Electric Lock shall have a separate lock rod attached to the vertical front rod.

D. Junction Boxes. Each Electric Switch Lock layout shall be installed with an individual pedestal mounted junction box. These junction boxes shall be as specified in Section 18360, Signal Systems Miscellaneous Products.

E. Electrical Fittings. All conduit, connectors, and electrical fittings, as required, for each electrical lock layout.

F. Switch Circuit Controller and Rod. Switch circuit controller layouts shall be installed as specified in Section 18330, Switch Circuit Controller.

G. Stranded wire: Furnish insulated No. 10 AWG stranded wire between the pedestal-mounted junction box and the switch circuit controller. Insulated wire shall be in accordance with Section 18370, Signal Wire and Cable.

2.02 SECURITY

A. Provisions shall be made for the use of standard padlocks:

1. A switch padlock to restrict entry into the operating handle location of the Electric Switch Lock.

2. Signal padlocks to restrict entry into the Electric Switch Lock operating mechanism, the circuit controller, and the junction box.

B. Padlocks will be Owner-furnished.

2.03 SOURCE QUALITY CONTROL

A. Perform Contractor’s acceptance test of each Electric Switch Lock layout prior to transporting the Electric Switch Lock layout.

PART 3 - EXECUTION

3.01 GENERAL

A. The circuits for Electric Switch Lock layouts shall be as shown on the Contract Drawings.

B. Mount and adjust the complete switch circuit controller layout as specified herein and as indicated on the Contract Drawings.

3.02 INSTALLATION

A. Install two 16-foot long timber ties or concrete ties for mounting the Electric Switch Lock where Alstom Model 9B or US&S Style SL-6A Electric Locks are used and controller by the Contractor, as shown on the Contract Drawings.

B. Mount Electric Switch Lock and controller on new and existing timber or concrete ties in conformance to Caltrain Design Standards.
C. Dap and drill timber ties to meet the requirements of these Specifications. Limit of cutting or dapping shall not exceed 2 inches.

D. Secure the Electric Switch Lock and switch circuit controller to the switch ties, by 3/4 inch by 10 1/2 inch bolts.

E. Remove any ballast necessary for the installation of each Electric Switch Lock layout and replace and tamp the ballast after the installation has been completed. Spread excess ballast evenly between ties in the vicinity of the switch and lock movement layout.

F. Make a preliminary adjustment of the Electric Switch Lock and switch circuit controller layout at the time of installation and a final adjustment when placing it in service, which shall result in the adjusting nuts being centered on the threads plus or minus 30 percent of the thread length. Make final adjustment at the time of the functional test. Make final adjustments in conformance with the requirements of AREMA C&S Manual, Parts 12.5.5 and 2.4.1.

G. Underground cable terminating in the Electric Switch Lock and switch circuit controller junction boxes shall be dressed and potheaded as specified in Section 18370, Signal Wire and Cable. Fan the individual conductors in a neat workmanlike manner, properly tagged and terminated. Wiring between switch junction box and Electric Switch Lock and switch circuit controller shall be No. 10 AWG insulated stranded flex wire. These wires shall also be tagged and terminated. Install the wires between the Electric Switch Lock and switch circuit controller junction box and the Electric Switch Lock and switch circuit controller mechanisms in an approved flexible conduit with a minimum length of 10 inches and a maximum length of 21 inches. Fasten this flexible conduit to the switch junction box and switch mechanism with appropriate connectors.

H. After installation, properly lubricate and maintain Electric Switch Lock and switch circuit controller layouts on a regular timed program until accepted by the Engineer.

I. Exercise care and ensure that the Electric Switch Lock and switch circuit controllers, including switch tie plates, are thoroughly lubricated at all lubricating points, that all machined surfaces susceptible to rusting, both external and internal, are thoroughly coated with grease, as acceptable to the Engineer, and that threaded portions of switch rods and nuts are similarly coated and protected.

J. Lubricate the switch tie plates with graphite lubricant, as acceptable to the Engineer. Thoroughly steam clean the plates to remove all oil or grease prior to application of the graphite. Periodically renew the protective coating until such time as the Owner assumes responsibility for maintenance of the equipment.

K. Connect electric switch lock rod and switch circuit controller rods to the normally closed switch point.
3.03 SECURITY

A. Install Owner-furnished padlocks.

3.04 TOUCH-UP

A. Touch-up finish of all equipment described in this Section in accordance with the AREMA C&S Manual, Part 1.5.10. Touch-up shall match factory finish.

3.05 FIELD QUALITY CONTROL

A. Inspect each Electric Switch Lock after it has been installed and correct any deficiencies noted. Conduct this inspection in conformance with the requirements of the Contractor's Installation Inspection Procedure as accepted by the Engineer.

B. Conduct the final operational tests of switch circuit controllers as described in 18600, Signal System Testing.

END OF SECTION
SECTION 18350
RECTIFIERS, BATTERIES AND BATTERY CHARGING EQUIPMENT

PART 1 - GENERAL

1.01 DESCRIPTION
A. Section includes requirements for rectifiers, batteries, and battery charging equipment.

1.02 REFERENCE STANDARDS
A. American Railway Engineering and Maintenance of Way Association (AREMA):

1.03 DESIGN REQUIREMENTS
A. Calculate the loads based upon the equipment proposed. Size all batteries to provide a minimum 48 hours standby capacity for all systems based on normal operating conditions. Verify the ampere-hour capacity shown on the Contract Drawings is adequate to provide a minimum of 48 hours standby capacity.
   1. Size battery to provide a minimum of 48 hours of uninterrupted power to the signal systems at the normal operating load.
B. Size batteries which provide power for crossing warning devices, such as gates and flashing lights, to provide 12 hours of continuous operation with the gate arms in the horizontal position and all lights flashing. This requirement is in addition to the requirement for 48 hours standby capacity in the previous paragraph.

1.04 SUBMITTALS
A. Load calculations of each dc and ac load. Submit calculations identifying normal and worst-case conditions for each load.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MATERIALS
A. SPL Batteries: Batteries conforming to the requirements specified herein as manufactured by Saft America, Inc. or Engineer approved equal.
   1. Model (SPL 340, 340AH)
   2. Model (SPL 380, 380AH)
B. National Railway Supply Battery Charger: Charger conforming to the requirements specified herein or Engineer approved equal:
1. Model ERBC (24/30 1/36V, 30A)
2. Model ERBC (12/40 1/20V, 40A)
3. Model ERBC (12/20 1/20V, 20A)

2.02 EQUIPMENT DETAILS

A. Battery charging equipment shall be designed for continuous operation.

B. Battery charging equipment shall be designed to deliver rated outputs with input voltage of 100 V to 130 V at 60 Hz, single phase, two wire input.

C. Battery charging equipment shall have a reserve capacity of at least 25 percent above the calculated high load requirements.

D. Each charger shall be provided with programmable output voltage adjustment.

E. Terminal markings for ac and dc terminals shall be permanent.

F. The charger shall provide a stabilized output voltage, temperature compensated with output current limiting. The capacity of the battery charger shall be determined by the Contractor and approved by the Engineer. The charger shall adjust its output current automatically, according to the load and to the demand on the battery.

G. Battery charger shall conform to requirements in AREMA C&S Manual Part 9.2.1. The output of the charger shall be sufficiently filtered to be compatible with the input voltage requirements of the solid-state interlocking units, and all other electronic equipment for the signaling system.

H. Batteries shall be recombination pocket plate nickel cadmium.

I. Batteries shall be capable of a minimum of 1,500 charge-discharge cycles to 80 percent discharge without loss of capacity. Totally discharged batteries, even if polarity has reversed, shall be capable of being recharged to rated capacity with charging voltage of no more than 1.60 volts per cell.

2.03 MISCELLANEOUS MATERIALS

A. Furnish all mounting hardware, terminals, and terminators, and similar items for mounting chargers and batteries in wayside cases and signal instrument shelters.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install batteries and battery charging systems as shown on the Contract Drawings.
3.02 TESTS

A. Perform tests specified in Section 18600, Signal Systems Testing, ensuring system operation.

B. Test batteries and battery chargers in accordance with the manufacturer’s standard when installed.

END OF SECTION
SECTION 18360
SIGNAL SYSTEMS MISCELLANEOUS PRODUCTS

PART 1 - GENERAL

1.01 DESCRIPTION
A. Section includes requirements for miscellaneous components and products for signal systems.

1.02 REFERENCE STANDARDS
A. American National Standards Institute (ANSI)
   1. C80.1 Electrical Rigid Steel Conduit
B. American Railway Engineering and Maintenance of Way Association (AREMA):

1.03 SUBMITTALS
A. Product Data: Submit manufacturer's catalog cuts, material descriptions, specifications, and other data pertinent to the miscellaneous products required.
B. Submit samples of solderless crimp-on type terminals.

1.04 EXTRA MATERIALS
A. Furnish two gallons or equivalent volume of corrosion preventive compound. Compound shall be the same product as approved for use in the Work.

PART 2 - PRODUCTS

2.01 GENERAL
A. All electrical components shall be rated to operate at power, voltage, current, and temperature levels exceeding by 20 percent those which the components will be subject to in service, unless otherwise specified herein.
B. Miscellaneous components and products shall be clearly and permanently labeled with value or type identification.

2.02 CIRCUIT BREAKERS AND FUSES
A. Circuit breakers and fuses shall be of suitable capacity to protect the various pieces of signal 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 Specifications.

B. Circuit fuses shall be non-renewable, and shall be of the fiber-case, time lag, fusion type.

C. 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.

D. All circuit breakers and fuses shall be centrally located on the power distribution panel and power racks.

E. Fuse clips shall be constructed so that they shall retain their resilience under all installation and service conditions, to ensure a positive contact between the clips and the fuse.

2.03 DIODES

A. Diodes to be furnished under this Contract shall carry a JEDEC number or shall be available from more than one manufacturer, and shall be used within the published specifications for such number. All diodes shall be silicon type, unless otherwise accepted by the Engineer.

2.04 RESISTORS

A. Resistors, other than those required for electronic circuits, shall be in accordance with AREMA C&S Manual Part 14.2.15.

2.05 REACTORS

A. Reactors, other than those required for electronic circuits, shall be in accordance with AREMA C&S Manual Part 14.2.20.

2.06 SIGNAL TERMINAL BLOCKS

A. Signal system terminal blocks shall be in accordance with the applicable recommendations of AREMA C&S Manual Part 14.1.5.

2.07 TERMINAL BINDING POSTS

A. Signal system terminal binding posts shall be in accordance with the applicable recommendations of AREMA C&S Manual Part 14.1.10.

B. Terminal binding posts for interface with plug-coupled wires to rack mounted electronic equipment shall be in accordance with the recommendations of AREMA C&S Manual, Part 14.1.2.
2.08 TERMINAL POST INSULATORS

A. All terminal posts, located on terminal boards in the wayside cases, signal instrument shelters used to terminate 50V, or greater, ac or dc circuits shall be provided with a protective insulator.

B. The type of insulator shall be individual for each terminal post and shall be fire-resistant.

2.09 INSULATED TEST LINK

A. Type 024620-1X as manufactured by Invensys Rail, or Engineer approved equal.

2.10 LIGHTNING ARRESTERS AND EQUALIZERS

A. Invensys Rail Clearview No. 022485-28X, Equalizer No. 022700-1X, or engineer approved equal. Lightning arresters and equalizers shall be mounted on accepted type base and shall be in accordance with the recommendations of AREMA C&S Manual Part 11.3.1.

2.11 SURGE PROTECTORS

A. Invensys Rail SP-17, SP-18, SP-19, SP-20, or equal. Surge Protectors shall be in accordance with the recommendations of AREMA C&S Manual Part 11.3.3.

2.12 TERMINALS FOR WIRES AND CABLES

A. Solderless terminals shall be in accordance with the recommendations of AREMA C&S Manual, Part 14.1.1, unless otherwise specified herein.

B. Terminals shall be of the solderless crimp-on type. Samples of all solderless terminals shall be submitted for approval.

C. Stranded copper wire shall be fitted with an approved type of terminal at all points where the wires are to be terminated on terminal binding posts.

D. The terminating means shall be of four types:

1. A lug for terminating heavy wires or signal power wires.

2. A solderless type of terminal as manufactured by TE Connectivity, Inc., under the trade name of "Pre-Insulated Flags" with translucent insulation similar to Catalog No. 322313, or equal, for terminating No. 16 and No. 14, American Wire Gauge (AWG) stranded wires.

3. An AMP Solistrand "Ring Tongue-Flat" terminal, similar to that shown on the AMP Drawing P64044, together with slip-on nylon post insulator, similar to that shown on AMP Drawing P64-0264, or equal, for terminating wires larger than No. 14 AWG to a maximum diameter over the insulation of 0.40 inch.

4. An AMP preinsulated; diamond grip ring nylon insulated wire terminal shall be used for terminating other stranded wires, No. 20 and No. 18 AWG,
having maximum diameter of 0.125 inch. AMP Catalog No. 320554, or equal, shall be furnished for No. 8 studs and AMP Catalog No. 320571, or equal, shall be furnished for 1/4-inch studs.

E. Terminals shall be for attaching to the ends of the conductor in such a manner that the flexibility of the conductor will not be destroyed and the possibility of breakage at the terminal will be reduced to a minimum.

F. Terminals shall be for attaching to the wire with a tool made by the manufacturer of the terminal and recommended by the manufacturer for the terminals being furnished.

G. The tool shall be equipped with a ratchet device to ensure proper indentation of the terminal, which will not release until proper indentation is complete.

### 2.13 TAGGING FOR CABLES, WIRES AND EQUIPMENT

A. Except as otherwise specified in this Section, permanently identify with a tag both ends of each cable, each cable wire, and all single wires that terminate in the junction boxes, switch mechanisms, signal instrument shelters, on equipment racks, relay bases, shelter and any equipment of the signal system outside of such locations. Install tags so that they may be read with a minimum of disturbance of the tags. Each conductor of the cable shall be rung out and identified before applying the tag. Tagging shall follow the three-line convention with the termination in the first line, nomenclature in the second line, and termination of the other end of the wire in the third line. (From - To)

B. Tags for wire and cable identification and for identification of transformers, resistors, reactors and other components shall meet the following requirements and shall be subject to Engineer’s acceptance:

1. **Sleeve Type Tags:**
   
a. Tags for identifying individual cable conductors and field-installed wires within the signal instrument shelters, wayside cases, switch mechanisms, switch layout junction boxes, base of signal junction boxes, and similar applications, shall be the sleeve type as manufactured by Raychem Corporation, Thermofit Marker System (TMS), or equal. The application of the conductor nomenclature shall be in accordance with the manufacturer's instructions and shall result in a permanently bonded and legible identification.

2. **Flat Plastic Tags:**
   
a. Tags for identification of vital relay plug boards, individual transformers, resistors, reactors, terminals, and other miscellaneous components within the signal instrument shelters, wayside cases, and outside terminal cases, shall be the flat plastic laminated type.
   
b. These tags shall be 1-1/2 inches long by 1/2-inch-wide. The untreated tag shall be milk white "vinylite", or Engineer approved equal.
c. The identifying nomenclature space shall allow for two rows of lettering, and the tag material shall be capable of receiving typed-on characters by conventional means. The height of the lettering shall not be less than 1/8 inch.

d. After lettering, both the face and backside of the tag shall be covered with a clear plastic coating, "vinylite", or Engineer approved equal.

### 2.14 HARDWARE

A. Mounting hardware exposed to the elements and used for signal equipment, cases, conduit, hangers, brackets, clamps, and the like, shall be hot-dip galvanized in accordance with AREMA C&S Manual Part 15.3.1, except as otherwise accepted by the Engineer.

B. Galvanizing:

1. The hot-dip process of galvanizing shall be used. All parts shall be picked so that all scale and adhering impurities are removed. The zinc coating shall be of commercially pure zinc, and shall be continuous and thorough. It shall not scale, blister, or be removable by any of the processes of handling or installation. The finished surface shall be free from fine line cracks, holes, or other indications of faulty galvanizing. It shall be smooth and free from adhering flux and other impurities. The edges and ends of parts shall be free from lumps and globules. Parts shall be coated with at least two ounces of zinc per square foot of galvanized surface, after all bending, cutting, drilling, and final fabrication.

C. Cadmium Plating:

1. Nuts, bolts, and washers shall be cadmium plated or stainless.

2. Cadmium plating shall be an impervious, dense, hard, fine grained, continuous, closely adhering coating of commercially pure cadmium, free from capillaries and shall completely cover the surface of the part in a smooth, bright layer. Plating on raised or prominent portions shall show no evidence of blackness or loose crystalline structure. It shall have a minimum thickness of six ten thousandths of an inch and shall withstand the salt spray test for at least 1,000 hours or an equivalent test accepted by the Engineer.

### 2.15 CONDUIT

A. Rigid conduit:

1. Steel Conduit: Steel conduit shall conform to ANSI C80.1 and shall be installed as shown on the Contract Drawings. Where elbows are used, they shall be long radius type. Steel conduits shall be protected in shipping and handling by approved thread protectors.
2. Polyvinyl Chloride (PVC) Conduit: Thick wall polyvinyl chloride conduit, high impact schedule 80, herein referred to as PVC conduit, shall be installed as shown in the Contract Drawings. Where elbows are used, they shall be the long radius type.

B. Flexible Conduit

1. Conduit for track circuit leads, switch-and-lock movements, and electric lock layouts shall be Liquid-Tite flexible conduit or equal. The conduit shall be clamped at both ends with stainless steel clamps. Clamps are not required for track wire risers.

2. Metallic Flexible Conduit: Where acceptable to the Engineer, metallic flexible conduit, Type UA, or engineer approved equal may be used.

C. Fittings

1. Approved fittings for flexible conduit shall be used.

2. Approved fittings for PVC conduit shall be used.

3. Fittings for rigid steel conduit shall be of cast malleable iron and shall be protected by hot-dip galvanizing.

2.16 PADLOCKS

A. Switch padlocks will be Owner-furnished.

B. Signal padlocks will be Owner-furnished. The Contractor shall provide temporary padlocks until such time the equipment is placed in-service.

2.17 SEALING COMPOUND

A. Sealing compound for use in sealing cable entrances shall be in accordance with AREMA C&S Manual Part 15.2.15.

2.18 CABLE ENTRANCE PIPES

A. Cable entrance pipes for wayside signal shelters shall be 4-inch PVC, Schedule 80, and 3 feet 6 inches long and extend 18 inches below the final grade.

B. Cable entrance for wayside signals shall be 4 inch Liquid-Tite flexible conduit or equal. Entrance pipe shall extend 18 inches below finished grade around signal.

C. Cable entrance pipes are not required where a cable chute directly enters a pullbox.

2.19 JUNCTION BOXES

A. All junction boxes shall be provided with gaskets to prevent the entrance of moisture and dust, in accordance with AREMA C&S Manual Part 15.2.10.
B. Junction boxes shall be provided to terminate underground cables at all switch and lock movements and all switch circuit controllers.

C. Junction boxes shall be provided with means for applying padlock.

2.20 LUBRICATION

A. Lubrication for switch tie plates for all switch and lock movement layouts installed by the Contractor shall be an accepted graphite lubricant, similar to Dixon's Graphite "Railroad 60".

2.21 ENVIRONMENTAL PROTECTION (CORROSION PREVENTIVE COMPOUND)

A. Protection, as hereinafter specified for machine-finished surfaces, threaded rods, nuts, and other parts that are susceptible to rusting or corroding, shall be a corroding preventive compound, NO-OX-IDE No. 90918, or equal. The product shall have sufficient body to resist weather and rusting for at least 6 months.

2.22 DC TRACK CIRCUITS

A. Transmitters shall be a 1TC, 2TC, or 3TC manufactured by GETS Global Signaling or Engineer approved equal.

2.23 STYLE C TRACK CIRCUITS

A. Transmitter shall be a TD-1A driven by an ACG-2T or TD-4 manufactured by GETS Global Signaling or Engineer approved equal.

2.24 AUDIO FREQUENCY ISLAND TRACK CIRCUITS

A. Audio frequency island track circuits shall be AFTAC-II manufactured by GETS Global Signaling, PSO manufactured by Invensys Rail, or Engineer approved equal.

2.25 AC TRACK CIRCUITS

A. AC Track Circuits shall be steady energy such as the SE-3 manufactured by Invensys Rail or Engineer approved equal. Vane Relays shall not be used.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Material and apparatus specified herein shall be installed in accordance with the details of respective Sections of these Specifications, manufacturer's recommendations, and in accordance with the Contractor's accepted installation drawings approved by the engineer.

END OF SECTION
SECTION 18370
SIGNAL WIRE AND CABLE

PART 1 - GENERAL

1.01 DESCRIPTION
A. Section includes requirements for all cable and wire required for signal and signal power system wiring to wayside shelters, junction boxes, and factory wired mechanisms.

1.02 REFERENCE STANDARDS
A. American Railway Engineering and Maintenance of Way Association (AREMA):

B. International Organization of Standardization (ISO):
   1. 9001 Quality Management Systems Requirements

1.03 SYSTEM DESCRIPTION
A. Material and workmanship shall be of the highest quality, assuring durability for minimum life expectancy of 40 years. Cables shall be suitable for use in the environment to be encountered on a railroad signal system, and shall be certified for continuous operation, in wet or dry locations, with no conductor failing in continuity or with loss of insulation to cross or ground less than one megohm.

1.04 SUBMITTALS
A. Product Data: Manufacturer’s catalog cuts, material descriptions, and specifications for each type of wire and cable the Contractor proposes to provide.

B. Quality Assurance: Submit a list of cable manufacturer’s installations complying with the past performance and experience requirements specified herein.

1.05 QUALITY ASSURANCE
A. Cable manufacturer’s qualifications shall be as follows:
   1. Past Performance and Experience: Demonstrated previous successful experience in supplying cable to the railway or transit industry for use as vital signal control cables. A list of such installations shall be provided for each cable manufacturer to be considered.
2. Quality Assurance Program: The manufacture of cables in accordance with the requirements of these specifications shall be accomplished in compliance with a Quality Assurance Program that meets the intent of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Shipping, storage, and handling shall be in accordance with the recommendations of AREMA Signal Manual, Part 10.4.1.

B. During storage and handling, prior to final conductor termination, cable ends shall be sealed to prevent the entrance of moisture.

PART 2 – PRODUCTS

2.01 INTERNAL WIRE AND CABLE

A. Individual cable make-up and conductor sizes shall be as shown on the Contract Drawings.

B. Internal wire and cable shall conform to the recommendations of AREMA C&S Manual, Part 10.3.14, and the following requirements:


2. Stranded conductors shall be Type II in accordance with AREMA C&S Manual Part 10.3.14.

C. Internal wire and cable insulation shall conform to the recommendations AREMA C&S Manual Part 10.3.24 and the following requirements:

1. The minimum insulation rating shall be 600 volts.

2.02 EXTERNAL WIRE AND CABLE

A. General

1. Individual cable make-up and conductor sizes shall be as shown on the Contract Drawings.

2. Conductors shall be soft or annealed copper, coated with tin in accordance with Type I wire as shown in the applicable AREMA C&S Manual Part.

3. Stranded conductors shall be soft or annealed copper, coated with tin in accordance with Type II wire as shown in the applicable AREMA C&S Manual Part.

B. Track Wire

1. Track wire shall be Okonite-Okolene(EP-PE) manufactured by Okonite Co., or Engineer approved equal.
2. Track wire shall meet the recommendations of AREMA C&S Manual, Part 10.3.15.

C. Signal, Switch, and Express Cable

1. Wire and cable used for direct burial to signals, to switches and express cable shall be Okonite (EP) Armored Underground Signal Cable manufactured by Okonite Co., or Engineer approved equal.

2. Conductors number six (#6AWG) and smaller shall be solid. Conductors number 4 (#4AWG) and larger shall be stranded.

3. Armored cable used for direct burial shall be furnished with a 10-mil flat bronze tape between the conductors and the outer jacket, helically applied, and adequately cushioned from the conductors.


5. Any cable installed in conduit or trough for its entire run need not be armored, but shall meet the recommendations of AREMA C&S Manual Part 10.3.16.

D. AC Power Cable

1. AC power shall be Okonite-FMR (EP) Okolon (CSPE) Type TC Cable manufactured by Okonite Co., or Engineer approved equal.

2. Cable shall meet the recommendations of AREMA Signal Manual, Part 10.3.16.

E. Modem Cable

1. Modem cables shall be C-L-X Type SP-OS manufactured by Okonite Co., or Engineer approved equal.

2. Modem cable shall be protected by a moisture impervious, continuously welded, corrugated, aluminum sheath with an overall EFTE fluoropolymer jacket.

3. Individual twisted pairs shall be separately shielded with an aluminum polyester tape to provide shield isolation between pairs of 100 megohms per 1000 ft. minimum.

4. Modem cable shall meet the requirements of AREMA Signal Manual, Part 10.3.17 except as specified herein.

2.03 SOURCE QUALITY CONTROL

A. Coordinate with the Engineer for Engineer’s inspections and tests at point of product.

B. Provide, at the point of production, apparatus and labor for the following tests:
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

**PART 3 - EXECUTION**

**3.01 INSTALLATION**

A. General:

1. The installation of wire and cable shall conform to AREMA C&S Manual Parts 10.4.1, 10.4.30, except as specified herein.

2. All external cable runs shall be direct burial or in conduit in accordance with the PCJPB Communication & Signaling Standard Drawings, and as called for in the Contract Drawings.

3. The Contractor shall separate signaling cables from parallel run of ac feeder cables, where adjacent locations are fed from one ac service location.

4. Give the Engineer 24 hours notice prior to installing cables.

5. Provide sufficient slack in cable conductors at all terminating posts to enable three terminations of the conductor, due to broken eyelets without re-servicing or repotheading the cable.

6. In certain types of installation, the cable cannot be constrained; therefore, ample cable slack shall be provided for additional flexibility due to vibration of such equipment.

7. Do not bend cables to a radius less than manufacturer’s recommendation.

8. Distribution cable runs shall be continuous without splices between cable terminating locations. Express cable runs longer than cable lengths shall be spliced together in junction box, instrument case, or other acceptable shelter. Prior to any cable or wire splicing, obtain the Engineer’s approval. Approval will not be granted for cables damaged by the Contractor or vandalized by others. It is the responsibility of the Contractor to protect all cables until final installation.

9. Identify individual cable conductors at each cable termination with plastic tags, as specified in Section 18360, Signal Systems Miscellaneous Products. Identify and terminate all spare conductors in each cable.
10. Seal cable entrance openings in equipment enclosures and junction boxes with either compression type fitting or pliable sealing compound after the cable is in place. Use sealing compound to seal the area around cable where the cable emerges from the end of a conduit or pipe. Seal and plug all spare conduits.

11. Wherever multiple conductor cables are terminated, carefully remove the outer sheath of the cable to a minimum point of 3 inches from the cable entrance. At the end of the cable sheath or covering, apply two layers of plastic electrical tape.

12. Terminate all cable conductors in conductor sequence from top to bottom.

13. Cable shields or sheaths shall be grounded at the entrance to signal shelters and shall float when terminated in field apparatus.

B. Underground Buried Installation

1. Bury cable to a uniform minimum depth of 36 inches as measured from bottom of tie to top of cable, unless installed in a cable trough. When paralleling the tracks, bury cable a minimum depth of 36 inches as measured from the finished grade to top of cable. Lay cable loosely in trench with a sand bed and backfill as specified in these Specifications. Install cable within four-inch PVC schedule 80 conduit at a uniform minimum cover depth of 36 inches below grade when passing under tracks.

2. Upon request and only under extreme circumstances because of installation hardship will installation of a cable be allowed to a depth of less than 36 inches, subject to the Engineer's acceptance. Protect the cable in a manner acceptable to the Engineer.

3. Whenever any signal cable is to pass under pavement or roadway, if existing conduit is not provided, install cable in a 4-inch PVC Schedule 80 conduit and extend conduit 2 feet beyond the edges of the pavement. Installation of conduits and pull boxes shall be in accordance with Caltrain Standard Drawings (SD-5000 series), for typical installations. Restore pavement or roadway to its original condition, subject to the Engineer’s acceptance.

4. Whenever any signal cable is to pass under the hot-mix asphalt concrete (HMAC) underlay installed at interlockings, install cable in conduit with pull boxes in accordance with Caltrain Standard Drawings (SD-5000 series).

5. Where cable leaves the ground at other than buildings or in foundations, protect cable by a bootleg or other covering extending above the ground line. Fill top of such protective coverings with a sealing compound.

6. Where buried cables enter a concrete foundation, junction box, shelter or case, leave sufficient slack in each cable in the nearest pullbox to allow an additional one foot of cable to be pulled into the shelter or junction box.

7. The potheading of buried cables shall be applied whenever cable is terminated in signal equipment, and such termination is within two feet.
of the grade level. This neoprene and seal pothead shall be installed in accordance with the manufacturer's instructions.

8. Cables shall not cross one another when they are pulled into a conduit or pipe; the conductors shall not be pulled tight or kinked in conduit fittings or boxes. All cables to be installed in a conduit or pipe shall be pulled and installed simultaneously.

9. Cables, track wire, and conduits shall be installed per Contract Drawings and Sections 02300 Earthwork.

10. All cables except final connection of flex wires to rail shall be installed in a conduit system as shown on the Contract Drawings.

C. Special Protection: 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. Replace any cable that is installed but subsequently damaged prior to acceptance as a result of the Contractor's failure to provide such special protection.

D. AC Power Cable

1. AC power cable shall be installed in dedicated conduit from the service meters to the signal shelters and between signal shelters.

3.02 REPAIR

A. Immediately call to the Engineer's attention any instance of damaged cable observed at any time, whether prior to installation, occurring during construction, or discovered by test observation after installation. The method of correction shall be in accordance with the Engineer's written instruction. Promptly repair such damage.

3.03 FIELD QUALITY CONTROL

A. Test all installed external cable in accordance with the requirements of Section 18600, Signal Systems Testing, and AREMA C&S Manual, Part 10.4.30.

END OF SECTION
PART 1 - GENERAL

1.01 DESCRIPTION

A. Section includes requirements for rail bonds, fouling bonds, frog bonds, track circuit connections, and all other material required for bonding of track circuit joints, track frog and switch bonding, and track circuit connections.

1.02 SYSTEM DESCRIPTION

A. Welded Bonds and track connections shall be in accordance with the requirements of PCJPB Standards.

B. Rail track joints shall be bonded with welded railhead bonds per PCJPB standards.

C. Track switch, frog fouling bonds, and track connections shall be stranded bonds.

D. Crimped sleeves shall not be used for any fouling or frog bonding unless allowed by PCJPB Manager of Signals and Communications through the Engineer.

1.03 QUALITY ASSURANCE

A. Install and test the track bonds in accordance with all applicable requirements of CFR 49, Part 236 and the recommendations of the AREMA C&S Manual, Part 8.1.20. When following the recommendations of the AREMA C&S Manual substitute the word "shall" for the word "should" in the applicable Manual Part.

1.04 SUBMITTALS

A. Product Data: Manufacturer's catalog cuts, material specifications, installation and maintenance instructions, and other data pertinent to the bonding material, staples, and circuit connections, specified herein and as shown on the Contract Drawings.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Rail Head Bonds: Railhead bonds shall be 3/16-inch in diameter with steel terminals welded to the conductors. They shall have a nominal length of 6 1/2 inches.

B. Web Bonds: Web Bonds shall be 3/16-inch, 12-inch long welded to the web.

C. Track Circuit Rail Connectors: Track circuit connectors shall be 3/16-inch stranded bronze conductor, 1-inch tap for welded connection on one end and compression sleeve on the other end for a direct crimp type connection to the
track wire, and shall have a nominal length of 4 inches. Use no crimped connections on fouling wires or frog bonding unless authorized by the PCJPB Manager of Signals and Communications through the Engineer.

D. Bond Strand: Bond strand for fouling wires shall be 3/16-inch single strand with 1/16-inch black PVC insulation.

E. Acceptable Manufacturers:

1. Erico International Corporation or Engineer approved equal.

PART 3 - EXECUTION

3.01 INSTALLATION OF WELDED BONDS

A. Install welded bonds at all non-insulated rail joints within the limits of this Contract that are not equipped with a bond.

B. Grind clean with a vitrified grinding wheel the surfaces of the rails where the bond is to be applied. After grinding, clean surface with an approved non-toxic solvent to remove all traces of grease and dirt. After the surface has been ground and cleaned, weld the bond wire to the rail in a manner that will ensure a thorough mechanical and electrical connection.

C. Before beginning work on these bonds, weld in the field, under conditions similar to those of the regular installation, not less than three complete bond connections, and as many more as the Engineer considers necessary to determine that the welds are being made satisfactorily. Such welds shall be subject to inspection and testing by the Engineer, and acceptance as to the method and quality of workmanship will depend on the results of these inspections and tests.

D. Ensure that each bond connection is thoroughly welded to the rail. The Engineer reserves the right to require a test of each weld by hammer and striker, or in any other manner, which in the opinion of the Engineer is reasonable.

E. Remove any welded bond installed by the Contractor that is found to be defective prior to acceptance, and install a new bond.

3.02 INSTALLATION OF TRACK CIRCUIT CONNECTIONS

A. The plug end of the track circuit connector shall be as specified herein, at a maximum distance of 3 inches from the end of the insulated joint.

B. Strip back underground cable a sufficient distance for the exposed conductor to be fully inserted into the compression sleeve. Then compress sleeve with the type of compression tool designed for that purpose.

C. Track wire installation shall conform to PCJPB Standards.
D. All track circuit connections shall be installed by the Contractor. Remove any found to be defective prior to acceptance, and install a new track circuit connection.

3.03 TESTING

A. Test all track circuits for continuity of circuit and ensure main line track circuit is de-energized with 0.06-ohm shunt at any point within the track block.

END OF SECTION
SECTION 18450
SIGNAL GROUNDING

PART 1 - GENERAL

1.01 DESCRIPTION
A. Section includes requirements for a grounding system for the equipment shelter and all other wayside equipment apparatus.

1.02 REFERENCE STANDARDS
A. American Railway Engineering and Maintenance of Way Association (AREMA):

B. ASTM International (ASTM):
   1. B8 Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

C. National Fire Protection Association (NFPA):
   1. 70 National Electrical Code (NEC)

1.03 SUBMITTALS
A. Submit Schematic Drawings showing the design and detail of the proposed grounding system for the signal and power equipment proposed to be furnished and installed.

B. Submit catalog cuts or drawings showing the type of components to be used for the proposed grounding system(s).

C. Submit Installation and Test Procedure proposed for all equipment grounding.

D. Submit test reports.

1.04 QUALITY ASSURANCE
A. Materials and equipment furnished and installed under this Section shall conform to all applicable State and local ordinances pertaining to electrical power installations and the National Electrical Code (NEC).
PART 2 – PRODUCTS

2.01 GENERAL

A. Ground rods shall be copper-clad stainless steel, in accordance with AREMA C&S Manual Part 11.3.4. The rod shall be at least 10 feet in length and at least 3/4-inch diameter.

B. Ground rod clamps shall be made of a cast bronze clamp body, with non-ferrous set-screws in accordance with the recommendations of AREMA C&S Manual Part 11.3.4.

C. Internal ground wire, from the equipment to the ground bus, shall be insulated No. 6 AWG standard copper wire in accordance with the recommendations of AREMA C&S Manual Part 11.4.1. Insulated ground wire shall be colored green.

D. Provide a grounding bus of nickel-plated hard drawn pure copper in the equipment shelters.

E. Bare Ground Wire: Soft drawn copper, Class A or Class B stranded, shall meet the requirements of ASTM B8. Sizing of ground wire shall be in accordance with the NEC, except where sizes specified herein or shown on the Contract Drawings are larger than those required by NEC; UL listed, Label A for lightning protection conductors. Grounding cable shall be continuous without joints or splices throughout its length.

F. Bolted Grounding Connectors: Use connectors made of high strength electrical bronze, with silicon bronze clamping bolts and hardware in accordance with AREMA C&S Manual Part 11.3.4; designed such that bolts, nuts, lock washers, and similar hardware which might nick or otherwise damage the ground wire, shall not make direct contact with the ground wire.

2.02 MATERIALS

A. Ground rods: As manufactured by Copperweld Corp. or Engineer approved equal.

B. Ground wire as specified herein.

C. Cadweld connections: As manufactured by Erico International Corp. or Engineer approved equal.

PART 3 - EXECUTION

3.01 INSTALLATION

A. General

1. Ground the following as described herein and in accordance with the applicable requirements of the National Electrical Code (NEC) and local city electrical codes: Service equipment, motor frames, switchgear and equipment enclosures, lighting and power panelboards, transformers,
raceways, fences and gates, building or structure steel frames, lighting standards, floodlight poles, and power/light pullboxes/maintenance holes.

2. The grounding system shall preclude any closed loop grounding arrangements.

3. Do not ground connection(s) to the track rails; do not use the neutral conductors of the ac power supply.

4. Grounding under these specifications shall conform to AREMA C&S Manual Part 11.4.1. In cases where these instructions differ, the Engineer will make final decision.

5. Ground wire/cable runs shall be as short and straight as possible and shall not be interrupted by any device.

B. Exterior: Equipment Shelter Grounding

1. At equipment shelters, drive four ground rods into the ground, one near each corner of a structure. At equipment cases, drive two ground rods into the ground, at opposite corners of the structure. The ground rods shall be a minimum of 6 feet apart and shall be driven below ground level. Dig a 12 inch deep trench between the ground rods. Electrically connect each of the ground rods connected to the others, using a No. 2 AWG bare stranded copper cable, welded using “Cadweld” or an equivalent thermal process. Coat Cadweld connections with epoxy resin. Place the ground wires in the bottom of the trench. Backfill trench, returning the soils removed during construction of the trench.

2. Cadweld shelter’s copper ground cables to the ground rods.

3. Ground resistance, as measured by the “Fall-Of Potential” method, shall not exceed 15 ohms.

4. Where flexible conduit is used, provide a bonding jumper.

C. Interior: Equipment Grounding

1. Equip shelters with a prime ground terminal securely attached electrically to the shelter structure and to the made ground network.

2. Run ground connections from lightning arresters and equipment chassis separately to ground buses in the shelters, as shown on Contract Drawings. Connect ground buses to the prime ground with green insulated No. 2 AWG stranded wire.

3. Properly ground equipment that is powered by or switches voltages greater than 35 volts ac or dc.

4. Properly ground equipment that has conductors that leave the shelter.

3.02 TESTING AND INSPECTION
A. Ground Resistance Testing: Verify that resistance between ground buses and absolute earth, as measured by the “Fall-Of Potential” method, does not exceed 15 ohms without benefit of chemical treatment or other artificial means.

B. Test Reports: Provide test reports to the Engineer upon completion of ground tests that completely describe ground resistance test procedures and test results. Test reports shall be signed by a technician and witnessed by a representative of the Engineer.

C. Prior to final acceptance by the Engineer, the Contractor shall have the new ac power service inspected by state and local jurisdictional authority(s) as required.

END OF SECTION
SECTION 18500
SERVICE METERS

PART 1 - GENERAL

1.01 DESCRIPTION
A. Section includes requirements for 120/240, 100A three-wire, single-phase meter service and upgrading existing meter service to 120/240, 100A, 3-wire, single-phase meter service.

B. Provide all interface with and in conformance to the standards of the power provider, in order to obtain the commercial metered power service at the locations shown on the Contract Drawings and as required by the Engineer.

1.02 REFERENCE STANDARDS
A. National Fire Protection Association (NFPA):
   1. 70 National Electrical Code (NEC)

1.03 SUBMITTALS
A. Submit Meter Service Drawings, indicating mounting pole, meter base, breaker box, and grounding.

B. Submit Peak load calculation for each meter location. Submit load calculation within 90 days of Notice to Proceed.

C. Submit letter certifying that the installation of the meter service has been approved by the local electrical inspector.

1.04 QUALITY ASSURANCE
A. Electrical service shall conform to the provisions in NFPA 70 National Electrical Code and these Specifications.

B. Materials and equipment furnished and installed under this Section shall conform to all applicable State and local ordinances pertaining to electrical power installations, and the National Electrical Code (NEC).

PART 2 – PRODUCTS

2.01 MATERIALS
A. Circuit Breakers
   1. Circuit breakers shall be sized by the Contractor for the projected loads. Circuit breakers for 120 Vac power shall be 2 pole rated for 240 Vac. Panels shall contain 25 percent spare circuit breaker space.
2. One double pole circuit breaker shall be provided for future use, in addition to the 25 percent space circuit breaker space, specified herein.

B. Meter Bases: Shall meet the requirements of the power provider.

C. Ground Rods and Ground Rod Clamps: Ground rods and ground rod clamps shall meet the requirements of Section 18450, Signal Grounding, and those of the power provider.

D. Wood Poles: Shall meet the requirements of the power provider.

E. Meter Pedestals and Bases: Shall meet the requirements of the power provider.

PART 3 - EXECUTION

3.01 GENERAL

A. Make the necessary arrangements with the power provider and pay all fees in connection with having the new meter service hooked up at least one month prior to placing signal system in service.

B. Arrange to obtain the service connection from the power provider. Pay the power provider charges for this service connection.

C. Where the Contract Documents specify that the Owner will make arrangements with the power provider, Contractor shall be responsible for installation and coordination with the power provider.

3.02 COORDINATION

A. Coordinate the connection and interface of new cables and equipment with the power provider in accordance with its standards.

3.03 INSTALLATION

A. The installation of the various equipment and materials for the signal power distribution system that are specified herein shall be in accordance with the power provider requirements and the NEC.

B. The requirements included within this Section shall cover all incidental installation work necessary to effect an integrated, tested, and operable signal power system for the Work as shown on the Contract Drawings.

C. Arrange utility power service at all equipment shelter locations requiring such services. Connections to equipment shelters from meter may be by underground or aerial connection. Where aerial connection is used, maximum aerial length between meter and shelter shall not exceed 125 feet without the Engineer’s prior acceptance.

D. In collaboration with the Engineer, meet as necessary with LPC representatives to negotiate for the upgrade, relocation, or addition of the power provider required power services needed to complete system operation.
3.04 GROUNDING

A. Meter service grounding shall be in accordance with Section 18450, Signal Grounding, the NEC, and the power provider requirements. If there is a conflict between the above specifications, the power provider requirements shall govern.

3.05 TESTING AND INSPECTION

A. Simulated load tests, in accordance with approved signal power system test procedure, shall be satisfactorily completed prior to final connection of signal facilities at each equipment location.

B. Prior to final acceptance by the Engineer, obtain inspection of the new AC power service by state and local jurisdictional authority(s), as required.

END OF SECTION
PART 1 - GENERAL

1.01 DESCRIPTION

A. Section includes requirements for tests and inspections to demonstrate that systems, subsystems, assemblies, subassemblies, and components supplied and installed under this Contract are in compliance with these Specifications and with all applicable regulatory requirements.

1.02 REFERENCE STANDARDS

A. Code of Federal Regulations (CFR), Title 49, Transportation:

1. Part 234 Grade Crossing Signal System Safety
2. Part 236 Rules, Standards, and Instructions for Railroad Signal System

B. American Railway Engineering and Maintenance of Way Association (AREMA):


1.03 TEST SYSTEM DESCRIPTION

A. It shall be understood where this Section states “as authorized by the PCJPB Signal Manager or PCJPB Signal Engineer” or “submit to the PCJPB Signal Manager or PCJPB Signal Engineer” such authorization or submittal shall be through the Engineer.

B. Tests and inspections shall be made both during the progress of this Contract and after completing installation of equipment, and shall consist of factory tests of Contractor Furnished equipment, circuit breakdown tests, wiring verification tests, continuity tests, resistance tests, voltage and current tests, applicable locking tests, operating tests, simulation tests, and other electrical and mechanical tests and inspections.

C. The work shall include all tests required to ensure proper and safe operation of all systems and subsystems, and to prove the adequacy and acceptability of the total installation specified herein. Tests to be performed shall cause each system and subsystem to be sequenced through its required operations, including imposition of simulated conditions to prove that the installation complies with all specified fail-safe requirements.

D. Each Contractor furnished component and unit of the wayside signal and highway grade crossing system shall have an inspection performed at its point of manufacture.
and evidence of this inspection and acceptability shall be indicated on the item where practicable.

E. Conduct an acceptance test on all Owner furnished equipment prior to loading at the warehouse. Provide certified acceptance reports with each unit at time of delivery.

F. Work shall include costs of the Contractor's personnel and any special equipment and assistance required to conduct all tests with complete documentation.

G. Test equipment of proper type, capacity, range, and accuracy shall be supplied by the Contractor to perform required tests and inspections.

H. Test equipment used shall be in good working order and properly calibrated within 6 months of the date of the tests. This equipment shall display a sticker indicating its calibration date and the agency that performed the calibration.

1. Calibration of each instrument shall be certified by a recognized testing facility. Instruments with out-of-date calibrations will be considered non-certified. Tests conducted with non-certified instruments will be rejected.

I. In the event that the system does not meet requirements, necessary corrections and retesting shall be made by the Contractor. The Contractor shall successfully complete all tests and inspections possible prior to performing final in-service tests.

J. Work shall include all necessary disconnecting and reconnecting in order to perform the specified tests.

K. Signal systems test work specified elsewhere in these Specifications shall be construed as related to and inclusive with the testing described herein.

L. Field tests shall be coordinated with the Engineer. As many tests and inspections as possible shall be completed prior to the final cutover to avoid train delay, inconvenience to the travel public, and cost to the Owner. The Contractor shall place systems in-service in phases where possible, thus reducing the actual cutover period.

M. Tests shall ensure conformance with CFR 49, Parts 234 and 236, and shall be recorded on forms provided by the Engineer and signed by the Contractor's Signal Engineer directing each test and inspection.

N. Tests and inspections shall conform to the PCJPB's Test and Maintenance Manual. Three copies of this Manual will be provided to the Contractor at the Pre-Construction meeting. Refer to Section 01200, Meetings. The Contractor shall request guidance from the Engineer where the test and inspection requirements written herein conflict with the PCJPB's Test and Maintenance Manual.

O. Testing, including pre-testing, shall include operating all switch machines and lighting all signals. The use of lamp simulators in lieu of, or in parallel with signal lamps will not be allowed in pre-testing. An exception may be authorized by the PCJPB Signal Manager or PCJPB Signal Engineer where a signal or switch
machine is in service and will be reconfigured for final cutover, or cannot be installed or wired until final cutover.

P. An appropriate meter shall be used when testing circuits. Visual observation of a relay is only valid when coil voltage or current or contact voltage, as applicable, is also measured.

Q. Test and inspection procedures shall be subject to the PCJPB Signal Manager or PCJPB Signal Engineer's acceptance and shall comply with all regulatory requirements and the manufacturer's recommended test procedure.

R. Notify the Engineer in writing at least 48 hours prior to each field test. No part of the signal system shall be placed in service without an authorized representative of the Engineer being present and witnessing the in-service tests.

1.04 SUBMITTALS

A. Submit the following pre-test information to the Engineer for acceptance:

1. Submit a Pre-testing authorization request 15 days in advance of proposed pre-testing. Such request shall include:

   a. Names of Contractor's Signal Engineer in charge of pre-testing.

   b. Other personnel assigned to the pre-test who will be performing the tests or assisting with the tests.

   c. List the assigned location(s) of the Contractor's personnel and their designated duties during the pre-test.

   d. An outline of the tests to be performed on each type of component, unit, or system, together with samples of the corresponding test records. The outline shall be arranged to indicate the proper sequence of each test to be performed on each component or unit. In addition, the date and time will be shown for each test.

   e. Description of each test to be performed, including the operating parameter to be tested. Test equipment to be used for the test, including the model number, serial number, calibration period, last calibration date and a brief description of the purpose of the test equipment.

   f. Description of equipment to be used for communication purposes.

2. Schedule of pre-testing Contractor proposes to perform which includes beginning and ending dates, times, and locations in a time-line format.

3. Identify any test or operation that may disrupt or disarrange the existing signal circuits or systems. Include description of proposed safety provisions and back-up contingency plans.
B. Submit the following in-service testing information to the Engineer for acceptance:

1. Submit, 30 days in advance of any in-service testing, a detailed cutover and in-service test procedure. This procedure shall indicate the Contractor’s personnel involved, their assigned location, and responsibility during the in-service testing. Include the following for Contractor-directed signal cutovers (the following does not apply to Owner-directed signal cutovers): The test procedure shall adequately reflect the test to be performed and the sequence in which the tests shall be performed. A signal aspect chart indicating the appropriate signal aspect to be displayed as train simulation tests are made shall be included. The signal aspect chart shall indicate the progressive down grading of signals and track codes and shall reflect the resulting signal aspect displayed as a result of a light-out condition.

2. The test procedure shall include an outline of the tests to be performed on each type of component, unit, or system, together with corresponding samples of test record forms and cards. The outline shall be arranged to indicate the proper sequence of each test to be performed on each component or unit; the numbers of each type of component or unit to be tested to demonstrate adequacy of design and quality control; and a line diagram showing the grouping and sequencing of system and subsystems.

C. Contractor’s testing procedures and cut-over plan must pass the PCJPB Signal Manager or PCJPB Signal Engineer’s and the Operating Railroads review. Contractor shall allow 30 days for this approval process.

D. Record the results of each test, as herein specified, and submit copies of the field test reports to the Engineer immediately at the completion of the cut-over testing. Prepare final type-written test reports as indicated herein and submit to the Engineer within five (5) days after the completion of each test. Final Type-written test reports shall include complete details of the test results and corrections or adjustments performed or which remain to be completed. The type-written test reports shall be signed and dated by the Contractor’s responsible employee. Furnish certified test results for tests performed by any subcontractors, when such tests are required within these Specifications.

E. Where required in this Section, submit test results on completed PCJPB test record forms.

F. Submit test reports for any additional tests required by the Contractor to ensure the safe operation of the system to the Engineer.

G. Upon completion of all tests, submit a letter certifying that all tests necessary to comply with all current regulatory requirements of these specifications have been performed.

1.05 QUALITY ASSURANCE

A. The Work and testing shall comply with the following standards and regulatory requirements: AREMA Communications and Signals Manual, Part 2.4.1. and CFR, Title 49, Parts 234 and 236. When following the recommendations of the AREMA
PART 2 – PRODUCTS

2.01 SITE TEST INSTRUMENTS AND EQUIPMENT
A. Test instruments and equipment necessary to conduct the tests specified herein shall be available, ready for use not less than one week in advance of test need. “Ready for use” shall mean properly matched for test parameters, properly calibrated, sufficiently supplied with leads, probes, adapters, stands, and similar items necessary to conduct the particular test in a completely professional manner.

2.02 TEMPORARY TEST MATERIALS
A. Temporary or interim test related materials, special tools, connections, jumpers, and similar items shall be furnished and available not less than one week in advance of the test need.

2.03 FACTORY TESTS AND INSPECTIONS
A. All wiring and equipment shall be checked to verify conformance to the Contract Drawings and the Specifications.
B. Each control point, intermediate signal, grade crossing warning system shelter or any other signal equipment shelter shall be tested to verify that it functions properly before it is shipped to the field for installation. These tests shall involve connecting all control systems (excluding signals, switches, and similar equipment) that make up a control point, intermediate signal, grade crossing warning system shelter, or any other signal equipment shelter; applying power; and then exercising each function of the system and verify proper result.
C. Confirmation shall be provided by the Contractor that all required factory tests of Systems, sub-systems, assemblies, sub-assemblies and components supplied under this Contract have been performed. Each component and unit shall be inspected at its point of manufacture and evidence of this inspection and acceptability shall be indicated. Certified test reports shall be furnished.

PART 3 - EXECUTION

3.01 FIELD TEST PROCEDURES
A. Perform as many pre-tests as possible in advance of in-service testing. Include, at a minimum, the adjustment of tunable joint couplers, microprocessor based coded track circuits, verify signal aspects against received and transmitted codes. Verify operation of, calibrate grade crossing prediction units, and adjust grade crossing signal control equipment as required to assure proper operation. In order to have a successful cut-over, it is essential that as much pre-testing and advance wiring be completed on the Main tracks before in-service testing begins.

1. Condition precedent for in-service testing and cut-over will be the completion of pre-testing and the PCJPB Signal Manager or PCJPB Signal Engineer’s
acceptance of the results. Complete pre-testing and submit the results to the Engineer not less than one (1) week prior to the proposed cut-over date.

B. The field tests performed shall cause each installed system and subsystem to be sequenced through its required operations, including the imposition of simulated conditions, to demonstrate that the installation complies with all specified fail-safe design requirements and operational functions.

C. Demonstrate the quality of installation by field tests for continuity, insulation resistance, resistance of ground connections, circuit breakdown, visual inspection, and any other tests required by these Specifications. Perform these tests prior to any operational testing of systems or subsystems.

D. The Contractor's test procedures shall consist of preprinted data sheets or inspection forms. Where applicable, results of test results shall be recorded on PCJPB forms. These forms will be provided by the Engineer. When completed by the field test personnel and checked for accuracy and completeness, submit the sheet as the test report.

E. When tests require specific meter or test instrument readings, the preprinted data sheet shall show the allowable range of values, for each part of the test. The test report shall also contain a check off system for each action and a blank space adjacent to the expected value in which to record the test readings.

F. All test reports shall be dated and signed by the responsible employee of the Contractor or subcontractor on the day the test is performed. Space also shall be provided for the signature of the witnessing inspector.

G. The report shall show the specific test instruments used on each test, with instruments identified by name, type, serial number, calibration date, and calibration due date.

H. Should an error be discovered during field testing due to field wiring and connections that do not agree with the accepted circuit plans, the Contractor may correct such errors without prior acceptance of the Engineer. The Contractor shall not, however, make any changes that deviate from the Contract Drawings without prior written acceptance of the Engineer.

I. The Engineer will make all final determinations as to whether only a part, or the whole test, shall be rerun when any specific field test does not meet the requirements specified for the test.

J. Any changes made after completion of test procedure shall be re-tested in accordance with the applicable test procedure and regulatory requirement.

3.02 GENERAL FIELD TESTS AND INSPECTION

A. Perform general field tests including the tests listed herein.

B. Ground verification test.

C. Dielectric Breakdown test of all vital circuitry.
D. Wiring verification of all non-vital circuitry.
E. Vital function tests.
F. Operating tests.
G. All applicable tests prescribed by AREMA C&S Manual Part 2.4.1, where the AREMA inspections and tests do not conflict with the requirements of these Specifications
H. All applicable tests as required to ensure systems comply with CFR 49, Parts 234 and 236.

3.03 SPECIFIC FIELD TESTS AND INSPECTION

A. Perform specific field tests listed herein.
B. Grounds:
   1. Ground resistance shall be tested and reported as described in Section 18450.
   2. All low voltage dc circuits shall be tested to verify that they are free of grounds.
   3. Contractor shall record test results on the appropriate PCJPB form and submit this completed form to the Engineer in order to obtain acceptance of this test requirement.
C. Insulation Resistance:
   1. Insulation resistance tests shall be made between all conductors and ground, and between conductors in each cable in accordance with FRA rule 236.108. The insulation resistance of wires and cables installed by the Contractor shall provide an “infinite” reading when using a direct reading instrument (megger) having a self-contained source of direct current test voltage. The megger scale shall have a minimum range of zero to 20 megohms and be rated at 250 volts minimum and 650 volts maximum.
   2. All insulation tests shall be performed after the equipment and cables are installed in the field.
   3. Contractor shall record test results on the appropriate PCJPB form and submit this completed form to the Engineer in order to obtain acceptance of this test requirement.
D. Vital Relays:
   1. All dc vital relays shall be tested for pick-up and drop-away values. These values shall be in accordance with field requirement values stated in Table I of AREMA C&S manual, Part 6.4.1.
2. Contractor shall perform all tests required to complete the appropriate PCJPB form.

3. These tests shall be performed at the shelter locations after the shelter has been set.

4. Contractor shall record test results on the appropriate PCJPB form and submit this completed form to the Engineer in order to obtain acceptance of this test requirement.

E. Energy Distribution: Energy-Off Tests: With all power to the signal instrument shelter or wayside case off, the following checks and tests shall be performed. These tests shall include:

1. Removing all fuses.

2. Verifying that circuit breaker size compares to that of Contract Drawings.

3. Comparing wire gages with those called for on the Contract Drawings. All discrepancies in wire sizes shall be replaced with the proper size wire.

4. During energy distribution breakdown, a wire count on each terminal, relay contact, etc. shall be taken to ensure that only the number of wires called for on the Contract Drawings is present at each terminal, relay contact, etc. Any discrepancies found shall be corrected and additional wires, if found, shall be removed.

5. Verify proper system voltage for each power supply, ac and dc.

6. Verify all power supplies for correct setting quantities.

7. Verify that no cross, shorts, or grounds exist.

8. Tags shall be verified for proper nomenclature and terminal location.

F. Breakdown of Control Circuits:

1. All circuits shall be tested in their entirety for the correct operation of and response to each contact on each circuit element, such as relays and contactors. Where parallel paths exist, the tests shall validate each path, and circuits shall be opened when required to ensure the proper test.

2. Each circuit shall be tested by simulating all operating conditions to verify that the circuit operates in accordance with the Specifications and accepted plans.

G. Electric Switch and Lock Movements (when applicable):

1. Continuity checks of field wires to switch-and-lock movements to verify all nomenclature.
2. Adjust throw bar so that proper tension is placed on switch points in both directions.

3. Manually operate switch machine normal and adjust lock rods and point detector rods to allow switch machine to lock up with no obstruction. Repeat above for switch machine in reverse position.

4. Turn on switch machine power, call switch machine normal and observe in field that switch machine corresponds to position called, and observe in wayside instrument shelter that proper switch correspondence relay is energized.

5. With switch machine called normal, check gaps on circuit controller contacts to see that they meet equipment specifications. Operate machine reverse and repeat.

6. Break down each contact in switch circuit controller and observe that proper switch correspondence relay drops. Repeat this procedure for both positions of the switch.

7. Place ammeter in series with motor control energy and adjust clutch such that it causes overload relay to pick up in less than ten seconds with 1/4-inch obstruction in switch point. Record current reading. Repeat for opposite position.

8. Place switch and lock movement in "hand" operation and observe switch mechanism cannot be operated by power. Place back in "motor" and verify that switch mechanism can be powered.

9. Operate switch, then shunt detector track circuit and observe that switch machine is stopped in middle of stroke and not allowed to complete movement. Remove shunt and verify switch completes movement.

10. Contractor shall record test results on the appropriate PCJPB form and submit this completed form the Engineer in order to obtain acceptance of this test requirement.

H. Signal Layouts: Tests shall be performed on all signal layouts. These tests shall include the following:

1. Continuity check of field wires and verification of all nomenclature.

2. Apply energy to signal lighting circuits and adjust all lamp voltages to 10 percent less than the lamp rating.

3. Sight signals for maximum visibility.

4. Check that light-out feature, where used, complies with FRA Rule 236.23(f).

I. Line Circuits: The purpose of this test procedure shall be to verify the integrity of line circuits between wayside instrument locations. These tests shall include the following:
1. All nomenclature shall be verified and line circuits tested for continuity.

2. Each repeater relay shall be tested to determine that it follows all the proper track relays de-energized in the signal shelters.

J. Control Office to Wayside Interface (when applicable): Upon completion of the wayside tests, a system test shall be performed to ensure continuity of operation of wayside equipment by the supervisory control system. This test shall consist of controlling all office wayside functions from the supervisory control console, and the transmission back to the control office of all indications from the field stations. The functions to be tested shall include the following:

1. Controls from Supervisory Control Console
   a. Control of switch machines.
   b. Lining of routes.

2. Indications to Supervisory Control Console
   a. Switch machine positions
   b. Track circuit occupancy.
   c. Signal indications.
   d. Power-off and alarm indications.

3. All design changes found necessary to obtain proper operation shall be submitted to the PCJPB Signal Manager or PCJPB Signal Engineer for acceptance.

K. Local Panel Test (when applicable):

1. Verify proper operation of all controls and indications.

L. Switch Circuit Controllers (when applicable):

1. Each switch circuit controller shall be tested to verify wiring, mechanical connectors, point obstruction, and point detection in accordance with AREMA C&S Manual, Part 12.5.1.

2. Contractor shall record test results on the appropriate PCJPB form and submit this completed form to the Engineer in order to obtain acceptance of this test requirement.

M. Track Circuits:

1. Each track circuit shall be tested for shunting sensitivity and polarity in accordance with the AREMA C&S Manual, Part 8.6.1.
N. Insulated joints:

1. Each insulated joint installed by the Contractor shall be tested with S&C Model 324 Track Circuit Short Finder, or Engineer accepted equal, and shall measure no less than 100 ohms across the joint.

O. Interlocking and Control Point Tests (when applicable):

1. A detailed list of the tests and complete test procedures shall be provided by the Engineer to establish safe and proper operation of interlockings. The Contractor shall provide the necessary personnel and equipment, along with support functions, as part of the Signal Test Crew. The test sequence shall be designed to test each function for correct performance, in accordance with these Specifications and the accepted plans. Furthermore, the test sequence shall include simulated unusual conditions to determine that the interlocking circuits will respond in a safe and desirable way.

2. The functions to be tested shall include the following:
   a. Time locking
   b. Route locking
   c. Verification of timing of time releases
   d. Indication locking
   e. Signal operation in accordance with route and aspect charts
   f. Interconnection with existing block signal systems
   g. Interconnection with existing interlockings. With an established direction of traffic, the controlled signal governing entrance to that particular route shall be put to stop. Traffic in the opposite direction shall not be established until a predetermined time has passed. This predetermined time shall be as indicated on the accepted plans. It shall be ascertained that time locking is effective for this test.

3. Time tests shall be as follows:
   a. Loss of shunt
   b. Time locking
   c. Flashing rate time

4. Contractor shall record test results on the appropriate PCJPB forms. Submit these completed forms to the Engineer in order to obtain acceptance of these test requirements.

END OF SECTION
SECTION 18700
HIGHWAY GRADE CROSSING WARNING SYSTEMS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Section includes requirements for highway grade crossing warning systems.

B. Where shown on the Contract Drawings or as required to accommodate associated other work of the Contract, make modifications to the existing highway grade crossing warning systems including such work as replacing, rewiring, or relocating of existing equipment or providing new control equipment and trackside equipment.

C. Provide continuous operation of the highway grade crossing warning systems in preparation for, and during, track installation and rehabilitation work.

1.02 REFERENCE STANDARDS

A. American Railway Engineering and Maintenance of Way Association (AREMA):


B. Code of Federal Regulations (CFR), Title 49, Transportation:

1. Part 234 Grade Crossing Signal System Safety
2. Part 236 Rules, Standards, and Instructions for Railroad Signal System

C. General Orders (G.O.) of the State of California Public Utilities Commission (CPUC) shall apply:

1. G.O. 75D: Protection of Crossing at Grade of Roads, Highways, and Streets with Railroads

1.03 SYSTEM DESCRIPTION

A. Furnish and install new train detection equipment, wideband shunts, narrowband shunts, tuned joint couplers, dummy loads, shunt housings, insulated joints, and track connections for designated existing crossings.

B. Provide continuous highway grade crossing warning during all phases of rail construction. Refer to Section 01011, Work Planning. At no time shall the work of the Contractor cause delay to train operation, cause an unsafe signaling condition to exist, or reduce the effectiveness or quality of the existing or new grade crossing warning systems.
C. Provide rail bonding for new or modified rail joints or turnouts as shown on the Contract Drawings. Provide rail bonding, as necessary, to maintain existing systems during construction.

D. Protect existing signaling cabling and, where necessary, relocate existing cabling in order to prevent damage to the cabling during track installation, profiling, or grade crossing work.

E. Record the final as-built conditions of the crossing warning system for each crossing.

F. Perform and document all tests and inspections in accordance with CFR 49 regulations and these specifications.

1.04 SUBMITTALS

A. Provide submittals for highway grade crossing devices, equipment, systems, assemblies, and detailed design in accordance with the requirements of Section 18000, General Signaling Requirements.

1. Submit, for approval by the Engineer, proposed plan for providing alternate methods of crossing warning during cutover and whenever the existing automatic crossing warning devices are deactivated, altered, or modified in order to accommodate construction work. Alternate methods shall conform to applicable parts of CFR, Title 49, including Part 234, and local ordinances.

2. Alternative Foundation Design: If the Contractor proposes foundations different from those shown on the Contract Drawings, submit drawings of the type of foundations, including size and details of the galvanized anchor bolts, nuts, and washers the Engineer's approval. Include structural calculations with loadings and wind shear parameters. The Contractor's alternate final design drawings and calculations shall be approved and stamped by a professional engineer registered in California.

B. Detailed Work Plan: The following work plan shall be coordinated with and integrated with submittals made under Section 01011, Work Planning. Submit a detailed work plan, for approval and coordination by the Engineer, prior to making the changeover from the existing crossing warning system to the new crossing warning system. The Contractor's proposed plan shall detail the amount of time the warning system will be out-of-service and the substitute warning which will be provided to allow normal railroad operations to be maintained. Change over of control, testing, and temporary-warning procedures shall be coordinated with the Engineer.

C. Submit for approval of the Engineer a procedure plan for conducting quality assurance, component integrity, circuit continuity, circuit breakdown, and system operation tests.

D. Submit product data for products furnished under this Section.
E. Submit documentation of acceptance testing.
F. Submit test reports.

1.05 DELIVERY, HANDLING, AND STORAGE
A. Package printed circuit cards separate from the constant warning time (CWT) units and all other electronic components with removable cards for shipment to the field. Protect each CWT unit and printed circuit card from damage or loss during handling and shipment.
B. Protect precast concrete foundation units during handling to avoid damage in transit and at storage locations. Support, cushion, and stack to protect the edges of the units. Replace chipped, cracked, or damaged units.

1.06 SPARE PARTS AND SPECIAL TOOLS
A. Refer to Section 01600, Materials, for general requirements for spare parts. Furnish for spare parts a constant warning type (CWT) crossing train detection equipment cabinet complete with modules for a two-track operation, associated surge panels, and programming keypad.

PART 2 – PRODUCTS

2.01 EQUIPMENT - GENERAL
A. Furnish materials and equipment for installation and for interconnection of the highway crossing warning as indicated on the Contract Drawings and specified herein. Materials and equipment shall be the products of manufacturers regularly engaged in the production of such material and equipment and shall be the manufacturer's latest design. Signaling materials and equipment shall be of a type and model that are in standard operation on major railway systems.
B. Only those existing materials and equipment specifically identified on the Contract Drawings for re-use, relocation, or modification shall be incorporated in the highway grade crossing warning systems. Materials and equipment shall conform to the provisions of AREMA Signal Manual, except as modified in this Section.
C. Furnish trackside equipment, such as tuned joint couplers, narrow band shunts, and wideband shunts, as shown on the Contract Drawings. Furnish equipment shelters, predictors, track filters, chokes, and other equipment as shown on the Contract Drawings and as required for complete installation.
D. Refer to Section 01600, Materials, for lists of Owner-furnished equipment. Conduct and document acceptance testing of all components prior to transporting them from Owner-designated storage location.

2.02 ELECTRICAL AND ELECTRONIC COMPONENTS - GENERAL
A. Design fusing and furnish fuses and printed circuit cards, connectors, and files in accordance with Section 18000, General Signaling Requirements.

2.03 CROSSING WARNING TRAIN DETECTION EQUIPMENT

A. Furnish constant warning time (CWT) type crossing train detection equipment, terminating shunts, surge panels, and arresters for the crossing configurations shown on the Contract Drawings.

B. Furnish each CWT unit complete with the basic complement of printed circuit cards and additional circuit card(s) for functions such as upstream detection, downstream detection, preemption initiation, event recording, and the like, as shown on the Contract Drawings.

C. Make CWT unit audio frequency assignments following manufacturers' application guidelines with special attention being paid to frequency versus approach length and placement of adjacent channel narrow band termination shunts. Acceptable primary frequencies in Hz are 86, 114, 156, 211, 285, 348, 430, 525, 645, 790, and 970. Constant warning time systems shall include a high frequency, AFO track circuit for the island circuit. Acceptable island frequencies are 10.0, 11.5, 13.2, and 15.2 kHz or the Harmon (GETSGS) Random Signature Island frequency.

D. Each highway grade crossing unit shall consist of a primary grade crossing CWT controller and a redundant standby grade crossing CWT controller. Provide an automatic transfer unit to transfer the approach control function from the primary CWT controller to the standby CWT controller in event of the failure of the primary unit and back to the primary unit if the standby unit were to fail. House the automatic transfer unit in the same cabinet as the CWT normal and standby controller.

E. Furnish constant warning time controller capable of detecting train movements on two separate track sections. Design CWT unit to allow selection of a different frequency for each track.

F. Constant warning time crossing train detection equipment shall be GETSGS (Harmon Electronics') Model HXP-3R2 or equivalent. Termination shunts shall be the CWT manufacturer's recommended type shunt for the frequency and application used. Furnish multi-frequency selectable termination shunts.

G. Furnish termination shunts, adjustable inductors, filters, code isolation units, and the like, as recommended by the CWT controller equipment manufacturer, as shown on the Contract Drawings.

H. Provide solid-state vital "AND" gate or equal as shown on the Contract Drawings.

I. The placement of the crossing approach start shunts shown on the Contract Drawings is based upon the maximum authorized train speed of 79 MPH and a crossing warning time of 25 seconds. Four seconds has been added to account for equipment reaction time. Additional time, if required to accommodate the individual crossings' unique characteristics or as required for traffic signal preemption requirements, shall be as specified in the Contract Documents. Take...
necessary field measurements at the grade crossing and verify that the crossing
warning time and shunt placement are valid for site conditions. Bring any
discrepancies to the attention of the Engineer.

J. Furnish data recorder with the CWT unit capable of recording train speed,
warning time, time and date, adjacent and auxiliary crossing detection times,
and equipment errors. The recorder shall be capable of furnishing a report with
only warning time, train speed, and time and date information and a separate
report that includes error data.

2.04 CROSSING WARNING GATES AND FLASHING LIGHTS

A. Furnish each highway grade crossing warning device assembly complete with all
associated hardware consisting of mast mounted gate mechanism, mast,
junction box base, gate arm, flashing light unit(s), bell, signs, and miscellaneous
hardware as shown on the Contract Drawings and as specified herein.

B. The crossing gate warning device assembly shall conform to the requirements of
CPUC GO No. 75D; CFR, Title 49, Part 234; and the recommendations of the
relevant sub-parts of the AREMA C&S Manual Section 3.

C. The gate mechanism housing shall be cast aluminum for mounting on a 5-inch
diameter 16 feet aluminum pole and furnished complete with mounting brackets,
counter-weight assembly, and counter-weights. Provide either single sided
counter-weight brackets or double-sided counter-weight brackets as
recommended by the manufacturer. Fit gate arm bracket with a breakaway arm
adapter as shown in the AREMA C&S Manual, Part 3.2.21.

D. The gate mechanism shall be of the power-up, power-down electro-mechanical
type complete with internal relay and adjustable snubbing resistor.

E. Furnish gate arms lengths required per PCJPB signal standards and site
conditions. Arms shall be of the aluminum with fiberglass extensions and
fiberglass tip type. Gate arm lamps shall be 4-inch diameter conforming to the
recommendations of AREMA C&S Manual, Part 3.2.40 except that LED lamps
shall be used. Provide high intensity lamps when shown on the Contract
Drawings. Fit lamp wiring harness with a five wire pull-apart connector for
interconnection to the gate mechanism and securely fasten to the gate arm.

F. Provide gate arm wind guards conforming to AREMA C&S Manual Part 3.2.22
with each gate assembly.

G. Provide flashing light crossing signal units as shown on the Contract Drawings.
Light units shall have 12-inch roundels with LED's and be complete with steel
backgrounds, steel hoods, junction box, and cross-arm brackets.

H. Provide a crossing warning bell conforming to the recommendations of AREMA
C&S Manual, Part 3.2.61 with each gate assembly, except that the bell shall be
mounted on the cantilever structure when a cantilever is shown.

I. Railroad crossing signs, multiple track signs, and the like, shall be extruded
aluminum, reflex-reflective sheet type as recommended in the AREMA C&S
2.05 FOUNDATIONS

A. Provide foundations for wayside equipment cases, highway grade crossing gates, flashers, and cantilevers as specified herein.

B. Precast or cast-in-place reinforced concrete foundations shall be monolithic or sectional construction and shall conform to the requirements for concrete work as specified in Sections 03300, Cast-in-Place Concrete, and 03400, Precast Concrete Structures.

C. Provide precast concrete foundations complete with anchor bolts, nuts, and washers in accordance with the recommendations of AREMA C&S Manual, Part 14.4.

D. All galvanized steel foundations to be furnished and installed shall be complete with Section 18360, Signal Systems Miscellaneous Products, and the recommendations of AREMA C&S Manual, Part 15.3.1.

E. Galvanized steel foundations shall be constructed of steel angle and plate welded together. Foundations shall be constructed of 2-1/2 inch by 2-1/2 inch by 1/4-inch steel angle and 1/4 inch steel plate.

F. Bolts, nuts, and washers shall be galvanized. Nuts and threads shall be in accordance with the recommendations of AREMA C&S Manual, Part 14.6.20. Plain washers shall be in accordance with the recommendations of AREMA C&S Manual, Part 14.6.21. Steel shall be in accordance with the recommendations of AREMA C&S Manual, Part 15.1.4, Section 1. Bolts shall be of sufficient length to provide for leveling of the device.

G. Place a conduit with a minimum 3-inch inside diameter in cast-in-place cantilever structure foundations for routing of cables to the cantilever junction box. The conduit shall protrude from the foundation sufficiently to enter cantilever structure ensuring cable is not exposed.

2.06 HARDWARE

A. Furnish hardware in accordance with Section 18360, Signal Systems Miscellaneous Products.

2.07 CONDUIT

A. Conduit shall conform to the specifications in Section 18360, Signal Systems Miscellaneous Products.
PART 3 - EXECUTION

3.01 GENERAL

A. Install and adjust equipment and materials in accordance with the appropriate requirements and recommendations of the equipment manufacturer, in conformance with the recommendations of the applicable parts of the AREMA C&S Manual; as required by CFR 49, Parts 234 and 236; applicable CPUC regulations; or as otherwise specified herein.

B. Where existing Grade Crossing Warning System Shelters and gate assemblies are indicated to be relocated, remove, protect, transport, store, disassemble, re-configure where necessary, reassemble and reinstall as shown in the Contract Drawings.

3.02 INSULATED JOINTS

A. Install insulated joints as specified in Section 20120, Track Appurtenances and Other Track Materials. Test each insulated joint in accordance with the requirements of the AREMA C&S Manual, Part 8.6.35, and per bonded joint and insulated joint section.

3.03 RAIL BONDING

A. Install new, or maintain existing, and test rail bonding for electrical continuity as required for continuous train detection within the approach limits of the crossings.

B. Double bond frog assemblies, switch points, and rail joints as specified in Section 18400, Rail Bonding, with the type of bonds specified in Section 18400, Rail Bonding.

C. Make signal connection to rails using weld type track circuit connectors per PCJPB standards.

3.04 CROSSING WARNING SYSTEM

A. Install, connect, and test new equipment and cabling to the greatest extent practicable without disruption of the existing highway grade crossing or signal systems.

3.05 TRACK CIRCUITS

A. Install and adjust all track circuits in accordance with the requirements of CFR49, Parts 234 and 236, the recommendations of AREMA C&S Manual, Parts 8.6.1, and as specified herein.

B. Make all track circuit rail connections using weld type connectors.

C. Adjust each track circuit for a detection sensitivity of 0.06 ohm throughout the length of the track circuit, including within the shunt fouling limits of turnouts.
D. Record voltage and current measurements at both feed and receive ends of each track circuit in a format approved by the Engineer.

3.06 HIGHWAY GRADE CROSSING EQUIPMENT

A. Install grade crossing warning equipment in conformance with CFR, Title 49 Part 234; CPUC G.O. 75D; approved submittals; and as shown on the Contract Drawings.

B. The final voltage adjustment and alignment of the flashing light units and final balancing of the gate arms shall be made at the time of the functional test. Final adjustments and alignments shall be made in conformance with the requirements of CFR 49 Part 234 and the recommendations of the AREMA C&S Manual, Parts 3.3.1 and 3.3.5 and.

C. Provide new cabling between the wayside gate/flasher and the crossing control shelter except where the Contract Drawings specifically specify the re-use of the existing cabling.

D. Install Owner-furnished/Contractor -furnished pedestrian gates in accordance with the Contract Drawings and installation instructions furnished by the Engineer.

3.07 FOUNDATIONS

A. Excavate, backfill, compact, and clean-up excavation as specified in Section 02300, Earthwork.

B. Install each foundation in accordance with the approved installation detail for each type of foundation and as specified herein. The absence of a specific task listing herein does not relieve the Contractor of the responsibility for providing a complete and functional installation. The installation tasks that must be completed by the Contractor are included herein.

C. Prior to placing precast foundation or constructing cast-in-place foundations, excavate completely to the lines and grades required and install crushed stone base in accordance with the requirements specified.

D. Install foundations to the lines, grades, and dimensions required as determined by the Contractor and approved by the Engineer. Install mounting bolts of sufficient length to accommodate use of leveling nuts between the base of the mechanism and the top of the foundation.

E. When placing foundations, ensure that anchor bolts have not been bent and that the threads are undamaged. Protect anchor bolt thread, washers, and nuts by applying friction tape, or other method approved by the Engineer, until such time as the wayside equipment is installed. Bring damaged anchor bolts to the immediate attention of the Engineer. Do not use damaged anchor bolts. Remove and replace damaged anchor bolts and completely or partially remove and replace foundation as determined by the Engineer.
F. Refer to Section 03170, Concrete Finishing, for requirements for finishing formed surfaces, smooth rubbed finish. Exposed poured concrete foundations shall be rubbed to obtain a uniformly smooth, clean surface of even texture and appearance.

G. Provide nonconductive material between the foundations and the mounted apparatus to prevent direct contact between the concrete and metal surfaces.

3.08 CONDUIT

A. Install conduit where shown on the Contract Drawings and as specified herein.

B. After conductors have been installed, seal ends of conduits terminating in instrument shelters, junction boxes, and equipment cases with an approved type of sealing compound.

C. Bore or jack conduit under the existing trackbed at any traverse, except that conduit may be placed under the track prior to the track renewal.

D. Place conduit to a minimum depth of 36 inches below finished grade except where specifically noted otherwise.

3.09 REMOVING, REINSTALLING AND SALVAGING EQUIPMENT

A. Relocate, reuse, modify, and salvage existing equipment as shown on the Contract Drawings. Refer to Section 02100, Demolition, for salvage requirements. Inventory existing relays and controlling equipment prior to delivering to the Engineer's designated storage location.

    1. Newly re-wire any existing equipment designated to be reused except where noted on the Contract Drawings.

B. Removed equipment and materials not designated for reuse or salvage shall become the property of the Contractor and disposed of. Refer to Section 02110, Site Clearing, for disposal requirements.

C. Change existing crossing warning systems over to the new systems as expeditiously as practicable. Remove retired equipment immediately and keep work site kept free of debris and packaging materials.

3.10 FIELD QUALITY CONTROL

A. Perform testing in accordance with Section 18600, Signal Systems Testing, including documentation requirements.

B. Prepare test procedures and perform and document tests on the highway grade crossing components and systems as follows:

    1. Include all tests herein specified, as specified in the FRA Rules, Standards, Instructions for Railroad Signal Systems, CFR 49 Part 234 and 236 and the appropriate sections of the AREMA C&S Manual.
2. Perform pretests on all procedures in advance of actual testing.

3. Perform applicable tests to each interim signal system, if any, before placing in service.

4. Actual testing shall be witnessed by the Engineer.

C. Make measurements at each piece of wayside equipment and record on the as-built record drawings verifying that the equipment is located where shown on the Contract Drawings and as approved by the Engineer. Verify, by measurement, that the equipment does not violate the train dynamic clearance envelope.

D. Test each grade crossing warning installation in accordance with Section 18600, Signal Systems Testing, and the AREMA C&S Manual, Parts 3.3.1 and 3.3.5. In addition, perform all applicable tests as described in the PCJPB Signals and Communications Test and Maintenance Manual, all manufacturer’s recommended test and adjustment procedures, and any tests required by regulation.

E. Disconnect and ground associated signal equipment not under test. Disconnect or unplug electronic devices or signal equipment prior to any testing.

F. Follow manufacturer’s instructions for testing of operation and electronic equipment.

G. Submit test data and results to the Engineer’s information and approval within 24 hours of placing the apparatus or system in operation.

END OF SECTION
SECTION 19100

VOICE RADIO COMMUNICATION SYSTEMS

PART 1 – GENERAL

1.01 DESCRIPTION

A. Section includes design and installation requirements for extension, upgrade, or retrofit of the existing VHF Voice Radio System.

1.02 REFERENCE STANDARDS

A. Design and installation shall be in accordance with the applicable codes and regulations, including the following:

1. National Electrical Code (NEC)
2. AREMA C&S Manual
3. CAL/OSHA standards
4. California Public Utilities Commission (CPUC) Regulations
5. State of California Electrical Safety Orders, Title 8
6. Federal Communications Commission (FCC) rules and regulations
7. Motorola R56 Grounding Standard

1.03 EXISTING SYSTEM DESCRIPTION - ABOVE-GRADE SUB-SYSTEM

A. Caltrain railroad consists of approximately 78 miles of railroad tracks serving freight and passenger operations between San Francisco and Gilroy. The railroad dispatch, operations and maintenance is served by a VHF Voice radio system which is configured as follows:

1. The VHF Voice Radio system consists of three distinct radio channels: a Road channel used to support train movement; a Maintenance of Way (MOW) channel used to support Operations and the Mechanical department; a Yard channel (aka Blue Flag). The Road channel is an analog, FM, narrowband (12.5 KHz) simplex channel operating on a frequency of 160.8150 MHz. The MOW channel is an analog, FM, narrowband (12.5 KHz) full duplex channel operating on the frequency pair: 161.5050 MHz for Base Station transmit and 160.5750 MHz for Base Station receive. The Yard channel is an analog, FM, narrowband (12.5 KHz) simplex channel, configured for independent local operation at the San Jose CEMOF and San Francisco 4th Street train yards.

2. A total of two independent dispatch work stations are located at the CEMOF, San Jose Centralized Control Facility (CCF). One of the two dispatch stations is responsible for supporting the “Northern” portion of the railroad, between MP (mile post) 0.0 and 44.0, and the second station supports the “Southern” portion of the railroad between MP 44.0 and 55.0

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VOICE RADIO COMMUNICATION SYSTEMS
on the Road channel. Between MP 55.0 and the southern end of the railroad, train movement is controlled by the Union Pacific Railroad (UPRR). Although each dispatch station is “stand-alone” or independent of the other, they are also fully redundant to each other, since they are individually capable of supporting rail vehicle movements for both the northern and southern territory of the railroad. The operation of the MOW channel at CEMOF is system wide for both consoles and is therefore not restricted to these North and South limits. The Road and MOW channels are both managed and controlled from the Voice Radio dispatch consoles located at the CEMOF control center. The Yard channel is monitored, but equipment movement is not controlled by the dispatchers.

3. A total of four “above-grade” Road Channel radio Base Station sites, which are located along the Right-of-Way (ROW), are each configured for carrier-squelch, simplex operation on the road channel frequency of 160.8150 MHz. A second carrier-squelch, simplex channel, operating on a frequency of 161.0700 MHz is used to support maintenance and “yard” operation but is repeated only in the vicinity of the San Francisco and San Jose yards using the 4th street and the San Jose Base Station towers respectively. Of the 4 Base Station sites, three are controlled by the “Northern Territory” dispatch, and one by the “Southern Territory” dispatch. Refer to Caltrain Standard Drawings SD-6000 series for further details. The MOW channel uses two “above-grade” Base Station sites located at the Monument Peak and San Bruno mountain top sites. Both Road and MOW channels also utilize four (4) “at-grade” tunnel Base Station sites, described in subpart 1.04 below.

4. The “Northern” Road Channel dispatch Base Station sites are listed in Table 1.1 below, along with their GPS coordinates.

<table>
<thead>
<tr>
<th>SITE NAME</th>
<th>GPS COORDINATES</th>
<th>SITE ELEVATION</th>
<th>ANTENNA AZIMUTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fourth Street Tower</td>
<td>N 37° 46’ 28.8” W 122° 23’ 50.2”</td>
<td>65 feet (55+10)</td>
<td>OMNIDIRECTIONAL Gain 0 dBi</td>
</tr>
<tr>
<td>Sign Hill</td>
<td>N 37° 39’ 53.8” W 122° 25’ 14.1”</td>
<td>576 feet (561+15)</td>
<td>156° Gain 8 dBi</td>
</tr>
<tr>
<td>San Carlos</td>
<td>N37° 30’ 23.4” W122° 15’ 43.1”</td>
<td>106 feet (99+7)</td>
<td>140° Gain 8 dBi</td>
</tr>
</tbody>
</table>

5. The lone “Southern” Road Channel dispatch Base Station site is listed in Table 1.2 below, along with its GPS coordinates.

<table>
<thead>
<tr>
<th>SITE NAME</th>
<th>GPS COORDINATES</th>
<th>SITE ELEVATION</th>
<th>ANTENNA AZIMUTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEMOF, San Jose</td>
<td>N 37° 20’ 20.28” W 121° 54’ 29.22”</td>
<td>138 feet (78+60)</td>
<td>314° /134° Dual Yagi. Gain 10 dBi</td>
</tr>
</tbody>
</table>

B. In addition to the four Base Station sites described above, there are three Dragging Equipment Detectors (DED) located along the ROW at MP 11.3 (between
Millbrae and San Bruno), MP 28.2 (between Menlo Park and Atherton) and MP 42.0 (between Santa Clara and Lawrence). Each of these DED sites is equipped with a VHF voice radio, configured to report wayside status to the train Engineer and the control center by transmitting this data on the same frequency as the road channel: 160.8150 MHz. More location details of the 3 DEDs are shown in table 1.3 below.

Table 1.3 Dragging Equipment Detector sites

<table>
<thead>
<tr>
<th>DED NAME</th>
<th>GPS COORDINATES</th>
<th>SITE ELEVATION</th>
<th>ANTENNA AZIMUTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.3/10.8*</td>
<td>N 37º 37' 42.2&quot;  W 122º 24' 37.0&quot;</td>
<td>15 feet</td>
<td>Rail Tx. OMNI Gain 0 dBi</td>
</tr>
<tr>
<td>28.2</td>
<td>N 37º 27' 36.4&quot;  W 122º 11' 25.9&quot;</td>
<td>36 feet</td>
<td>Rail Tx. OMNI Gain 0 dBi</td>
</tr>
<tr>
<td>42.2</td>
<td>N37º 22' 11.5&quot;  W121º 58' 27.6&quot;</td>
<td>44 feet</td>
<td>Rail Tx. OMNI Gain 0 dBi</td>
</tr>
</tbody>
</table>

* This DED relocated to 10.8 in 2011

1. The DEDs are transmit-only devices, located along the ROW. They utilize a Harmon Electronics (West Coast Operations) WCO-46 “talker-system” which contains a discrete Motorola HT-440 VHF voice radio connected to a small roof mounted omni-directional antenna. Currently the DEDs transmit each time a train passed by, however this is being changed to an exceptions based configuration, in which DEDs will transmit only upon detection of a problem.

1.04 EXISTING SYSTEM DESCRIPTION - TUNNEL SUB-SYSTEM

A. The terrain between the Fourth Street and the Sign Hill Base Station sites is fairly rugged, with several small, but steep hills in the path of the railroad. In 4 such locations, the railroad tracks are built through tunnels inside these hills. Each tunnel is between 1000 and 3800 feet in length and is equipped with a small, stand-alone radio Base Station located at the south entrance to the respective tunnel. Each of the four tunnel Road-channel radio Base Stations is identical to the 4 above-grade Road-channel radio base stations except that each tunnel radio Base Station is connected to a distributed antenna system, which is installed inside each tunnel to support radio communications inside the confines of the respective tunnel. Each tunnel base station is also connected to a low profile external antenna to provide coverage to the approach/exit of the southern end of the respective tunnel. Additionally, each of the four tunnels is equipped with a MOW base station radio. The Road and MOW channels are transmitter combined and receiver multi-coupled to/from the same antenna system. Refer to the drawings for details. The recovered audio signal from each of the four tunnel Road-channel radio receivers is sent to San Jose via separate leased-lines into a voting comparator to select the best audio signal to present to the dispatcher. The recovered audio signal from each of the four tunnel MOW radio receivers along with the two above-grade base station receivers is voted (compared using a comparator assembly, and from which the signal with the best RSSI is selected) in the same manner in order to select the best audio signal to present to the above-grade, wide area transmitter.
1.05 EXISTING SYSTEM DESCRIPTION - MOBILE USERS

A. Each locomotive and cab car operating between San Francisco and Gilroy is equipped with a VHF-voice mobile radio. Refer the technical specification details of the mobile radio equipment specified in Part 2 of this Section. Each mobile radio is programmed and configured to operate in carrier-squelch simplex mode on the “road” and the “yard” (aka “blue flag”) channels, and carrier-squelch full duplex mode on the MOW channel. Likewise all mobile and portable radios used by Caltrain operations and maintenance personnel are programmed to operate on each of the three carrier-squelch channels.

B. During the peak commute hour, there may be as many as seventy (70) locomotive/cab car radios and two hundred (200) mobile and portable radios in use on the VHF voice radio system. They contend, along with the three DEDs for road-channel “air-time” to access the four (4) above-grade Base Station sites in order to communicate with the dispatcher. In addition, these users contend with each other and with the 3 DEDs in order to communicate with each other (only when in close proximity) using the simplex radio-to-radio mode. Similar user contention for access to the four (4) Tunnel Radio Base Stations occurs, except due to logistical reasons, no more than about six (6) locomotives and a slightly greater number of mobiles and portables radios will be within range of these four tunnel Base Station sites. The same holds true for the MOW channel, except that the number of users vying for control/use of the channel is significantly less because it is not used for dispatch.

1.06 FUNCTIONAL REQUIREMENTS

A. Footprint and Reliability: The following table defines the footprint and reliability of the cumulative VHF voice radio coverage that shall be provided by the 4 above-grade Base Stations and independently by the 4 tunnel radio Base Station sites. The radio coverage required from the dragging detectors shall be of the same quality, but limited to +/- 3 miles along the ROW.

B. Although Signal to Noise-and-Distortion (SINAD) is the only objective measure of the quality of the radio coverage, the Contractor will be permitted to test the quality of radio coverage using more expeditious measures such as Circuit Merit (CM), Delivered Audio Quality (DAQ) or Signal Strength, provided the Contractor first establishes the correlation between the measure used in the testing and the 20 dB SINAD criterion. Refer to Part 3, 3.02 “Testing” for details of the testing required.

C. All Voice Radio channels are configured for Narrowband operation. Narrowband is currently defined by the FCC (circa 2011) as occupying a channel bandwidth of 12.5 KHz with a transmitter deviation not to exceed ±2.5 KHz. This definition will eventually change to a bandwidth, or bandwidth equivalency of 6.25 KHz by about the year 2018.

D. Frequency And Configuration: One simplex radio channel (the Road Channel) is utilized to coordinate all dispatch operations. It is broadcast along the entire ROW. A second simplex channel, the Yard (aka Blue Flag) channel is used to support maintenance and yard related activities and is only broadcast within the confines of the two “yard” locations along the ROW. The third channel, (called the MOW channel) is configured as full duplex, and, repeated along the entire ROW, as well as on most of the Peninsula and surrounding areas to serve the requirements of operations and maintenance.
### Table 1.4 Radio Coverage Footprint and Reliability

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>PERCENT GEOGRAPHIC COVERAGE</th>
<th>MINIMUM EIA SINAD/CM/DAQ LEVEL</th>
<th>PERCENT OF TIME RX / TX. LEVELS ≥ MIN. LEVELS</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Along the ROW</td>
<td>99</td>
<td>20/4/3,4</td>
<td>95/95</td>
<td>To Trains &amp; Trackside</td>
</tr>
<tr>
<td>Within 500 feet of Trackside</td>
<td>95</td>
<td>20/4/3,4</td>
<td>95/95</td>
<td>To Portable &amp; Mobile Radios</td>
</tr>
<tr>
<td>Inside the tunnels</td>
<td>99</td>
<td>20/4/3,4</td>
<td>95/95</td>
<td>To Trains &amp; Trackside</td>
</tr>
<tr>
<td>Around DEDs</td>
<td>99 centered +/- 3 miles along ROW</td>
<td>20/4/3,4</td>
<td>95/95</td>
<td>Plus or minus 3 Miles along ROW</td>
</tr>
</tbody>
</table>

E. **Dragging Equipment Detector**

1. Each DED shall report wayside status immediately after the passage of a train. This report must be made on the road channel, so that it can be heard by the train Engineer, in the event that there is a problem, in which case the train can be brought to a stop immediately.

2. The report from each DED shall also be recorded, either at the CEMOF, or in equipment mounted along the ROW. The decision regarding where the DED recordings are made, shall be made on a case by case basis, with all DEDs whose RF transmissions cannot establish a viable communication link with one base station site, when the output power is reduced in order to limit the range to +/- 3 miles along the ROW, being recorded along the ROW. This requirement means that each DED, which is not recorded along the ROW, shall have a reliable communication link to at least, but no more than one Base Station site located in the Northern or Southern territory, corresponding to the location of the DED.

3. Supply Motorola HT-750 or Engineer approved equal for use as the radio interface to the dragging equipment detector.

F. **Voice Recording:**

1. All voice radio communications that require the use of a Base Station site must be recorded at the control center, per FRA regulations, however, because all voice radio communication (even those localized communications utilizing the radio-to-radio mode) will be recovered by at least one Base Station site, then, in effect, all Voice Radio Communications will be recorded at the CCF.

2. The voice logging recorder shall record to a hard-disk or silicon storage drive with an analog interface to the Caltrain voice radio and telephone services. The Voice Recorder shall be capable of supporting a minimum of thirty six (36) channels. The voice recorder shall support a network storage interface, with a minimum of 5 TB of storage and a compression
ratio of 6:1 or higher. Supply a NiceLog NCF3B-24 or Engineer approved equal.

G. Tunnel Base Station Sites

1. The receive audio from the four tunnel Base Station sites shall be voted and only the best quality signal from the four tunnel sites shall be presented to the Dispatch Console. The voters, which are manufactured by JLP/Raytheon, shall be compatible with the EIA (Motorola) signaling tones required to control the GE Mastr III Base Stations.

2. The tunnel radio Base Station sites shall be equipped with an external antenna system extension. This external antenna extension shall be utilized on the south end of each tunnel, with the region outside the north end of each tunnel supported by the antenna extension of the next tunnel to its north. A high gain directional antenna shall be used external to each tunnel in order to extend the radio coverage around the hilly regions adjacent to these tunnels.

H. Dragging Equipment Detectors: The transmit power of each DED shall be reduced to provide an ERP, (dependent on the terrain in the immediate vicinity of the DED) that will restrict radio coverage to provide a receive intensity of \( \geq -109 \) dBm (\( \geq 3 \) watts) within a ± 3 mile region of track. The transmit ERP required to achieve this shall be determined by the Contractor based on the use of radio coverage simulations and field tests.

I. Communications Back-haul

The Communications back-haul serves to connect the CCF (located at the CEMOF in San Jose) with the various Voice Radio Base Station sites through which the dispatchers at the CCF communicate with trains and with field personnel.

The existing voice radio communication backhaul uses leased 4-Wire Point-to-Point (4W PTP) circuits from AT&T between the CCF and the following Voice Radio Base Station sites: 4th Street, Sign Hill, San Carlos and Tunnels 1 to 4.

The MOW voice radio communication backhaul uses an Agency-owned Microwave Radio network between the CCF and the following MOW Radio Base Station sites: Monument Peak and San Bruno Mountain.

The voice radio communication backhaul between the voice radio Base Station co-located at the CEMOF facility is provisioned via a twisted-pair 4-Wire circuit, less than 100 feet in length.

Refer to Caltrain Design Criteria, Chapter 6, Train Control Communication for further details of the existing voice radio communications back-haul.

J. Narrow-banding

1. History

In 1995, the FCC issued a mandate, with rules to address more efficient use of the increasingly crowded frequency spectrum. All licenses below 512 MHz were required to migrate from the default 25 KHz bandwidth to
a 12.5 KHz bandwidth, within 10 years and eventually to a 6.25 KHz bandwidth within 18 years.

This timetable proved too difficult to meet, and after several stays, the FCC issued the "Third Memorandum Opinion and Order (3rd MO&O)" in December 2004 that set January 1, 2013 as the deadline by which all licenses operating below 512 MHz must be converted to the 12.5 KHz FCC emission designation and operation. Currently, equipment designed solely for 25 KHz bandwidth operation is no longer available, and is rapidly being replaced by equipment designed to operate on either 25 KHz or 12.5 KHz (user configurable by a minor software/code-plug change)

Notes:

i. In anticipation of this mandate, all voice radio equipment purchased/specified by Caltrain in the last 8 years is 25 KHz/12.5KHz capable.

ii. In spite of the 1/1/2013 deadline, the FCC will still accept new applications for 25KHz operation up until 12/31/2010, however after 1/1/2011, the FCC will force equipment manufacturers to be capable of operating on 6.25 KHz bandwidth.

iii. In an ideal world, Caltrain should be migrating from 25 KHz bandwidth directly to 6.25 KHz bandwidth, to avoid having to perform a second narrow-banding effort later, but there are technical constraints, not anticipated by the FCC that will prevent this. See below for details.

All Caltrain FCC transmitters licensed below 512 MHz will be significantly impacted by this task order. Specifically, all VHF Voice Radio frequencies shall be converted to narrow-band emissions.

In order to reaffirm this “Third Memorandum Opinion and Order”, the FCC will occasionally generate press releases, such as the one below, released in March 2007.

Note also that the FCC will ultimately mandate the conversion from 12.5 KHz narrow-band operation to 6.25 KHz narrow-band operation. This was originally a part of the Third Memorandum Opinion, set to occur in 2018; however, the FCC has backed away from that date until it can better understand the technologies required to efficiently support this migration.

The problem is, whereas a single analog FM radio can support both 25 KHz and 12.5 KHz operations, (user configurable by a minor software/code-plug change), the same is not the case for operation on 12.5KHz and 6.25 KHz. This is because operation at 6.25 KHz requires digital audio compression and expansion techniques that are incompatible with analog FM audio.

Nonetheless, at some point, Caltrain will be required to operate at 6.25 KHz bandwidth, probably after the year 2020. Unfortunately, operation at 6.25 KHz, either via a second narrowband conversion, or via the use of modulation/access efficient schemes such as FDMA and TDMA, will
require a “forklift” replacement of all Voice radio infrastructure (Base Stations) and subscriber (portable and mobile radio) equipment.

The following is the most recent FCC press release regarding narrowbanding:

The FCC released a Third Report & Order on March 26, 2007 affirming narrowband deadlines affecting Part 90 frequencies allocated between 150 – 174 & 421 - 512 MHz and further encourages more efficient use of this spectrum. The action taken by the Commission was included in WT Docket Number 99-87. Key decisions are as follows:

The FCC declined to establish a fixed date for users to transition to 6.25 kHz technology.

§ The Commission indicated they would later adopt a date when users must migrate to 6.25 kHz technology. On January 1, 2011 applications for equipment certification will be granted only if the equipment either (1) is capable of operating on 6.25 kHz channels, or (2) meets a narrowband efficiency standard of 4800 bits per second per 6.25 kHz of channel bandwidth.

§ Licensees are urged to consider the feasibility of migrating directly from 25 kHz to 6.25 kHz prior to January 1, 2013, as this may prove more cost efficient than going to 12.5 kHz technology by 2013 then further migrating to 6.25 kHz technology again later.

§ The purpose of this interim deadline is to encourage licensees to begin planning and implementing migration to narrowband technology well before January 1, 2013.

For the complete order see:


2 Technical Specifications

All Caltrain Voice Radio frequencies operating below 512 MHz and above 80 MHz shall be reconfigured to operate on a bandwidth of 12.5 KHz. To the extent that this configuration reduces the radio coverage footprint, the design of the radio system shall be adjusted to mitigate this. This configuration, and the resulting coverage shall be completed, tested and cut-over to service prior to January 1, 2013.

Caltrain shall, in coordination with tenant railroads and with the AAR explore options of converting to a narrow-band system capable of meeting a narrowband efficiency standard of 4800 bits per second per 6.25 kHz of channel bandwidth in order to avoid having to perform a second narrow-banding upgrade by or before the year 2020.

1.07 DESIGN REQUIREMENTS

A. Design extension, upgrade or retrofit of the VHF Voice Radio System, as applicable. Design shall be in accordance with applicable FCC rules and regulations.
B. Design Prerequisites: Execute and submit design of the Radio System in four iterative parts: the 30 percent, 65 percent, 100 percent, and Issued for Bid/Construction (IFB/C).

C. SCADA Interfaces: Equip Radio Base Station sites with Alarm monitoring and remote control/command interfaces that shall permit the Dispatcher at the CCF to monitor Alarm conditions at each site, as well as remotely reboot any component of the Base Station that is micro-processor based. The Base Station shall be interfaced to a SCADA system provided by others. The SCADA system shall be capable of reporting to the existing Train Control server.

1. As a minimum, the following alarms shall be provisioned:
   a. Low/ Loss of RF Power
   b. High VSWR
   c. Loss of AC Power
   d. Loss of DC Power
   e. Rectifier failure
   f. High Temperature
   g. Door Open

2. Each alarm shall be activated via a dry contact relay pair, which shall be normally open.

D. Radio Coverage Simulations:

1. Utilize computer simulations to predict the VHF voice radio coverage and traffic for all new Base Stations or DEDs added. These computer simulations shall utilize terrain data with a resolution no worse than 30 meters. Use the NAD 83 (2007) or later geodetic datum. Utilize a color gradient to display both the uplink and downlink coverage predictions, with each color representing no greater than a 10 dB gradient. Perform simulations for each of train and portable radio user types located within 500 feet on either side of the ROW.

2. In order to predict the quality of radio coverage inside tunnels, construct a Radio Frequency Power Budget, using Microsoft Excel or a similar spreadsheet program. Construct one power budget for each frequency band / user and for each direction (uplink / downlink).

3. To assure a communications reliability of 99 or 95 percent where specified, factor a fade margin of 17 dB or 10 dB respectively into all radio coverage simulations and all power budget analysis.

E. Intermodulation Studies: For all new installations with three or more transmit frequencies, or those with less than three transmit frequencies but more than two external adjacent frequencies (of power, measured internal to the new system, within 10 dB of the power of the transmit frequencies) that cannot be removed with notch filters, construct and execute an intermodulation study. This study
shall examine all receiver intermodulation products created from the mixing of these transmit frequencies. For installations inside tunnels which use Bi Directional Amplifiers (BDA) in addition to the study defined above, perform a second intermodulation study which examines the mixing of multiple receive frequencies and separately multiple transmit frequencies inside an amplifier.

F. Structural Design: Provide structural design for new lattice, monopole or tilt-down towers, tower foundations, and civil structures associated with new installations required for the work of this Section. Design shall take into account specific soil types at each site. Drawings and calculations shall be signed and sealed by a Civil/Structural professional engineer licensed in the State of California. Designs shall be based on the use of a geotechnical report prepared for the respective site(s) and shall include all calculations using maximum weights and wind loads supported by the towers.

1.08 SUBMITTALS

A. Design Submittals: Submit design documents in four phases in accordance with approved submittal schedule. Obtain the Engineer’s approval of each part before proceeding to more advanced parts.

1. 30 percent design document
2. 65 percent design document
3. 100 percent design document
4. Final design document
5. Issued for Bid/Construction and As-Built drawings

The 65 percent, 100 percent, IFB/C and As-Built drawings shall, at a minimum, include the following documents:

  a. Radio Coverage Simulations
  b. Intermodulation Studies
  c. Grounding and Lightning Protection. In accordance with requirements indicated on the Contract Drawings, submit detailed drawings depicting the grounding configuration proposed for each radio site
  d. Structural Design Calculations and Drawings
  e. Radio “code plugs”
  f. Configuration management documents

B. Obtain Engineer’s approval of any deviations from the specified design requirements. Submit request explaining the reasons for deviations and a description of the deviation itself for approval.

C. Product Data and Shop Drawings: Submit product data and manufacturer shop drawings at least 60 days prior to start of any installation.
1. Submit product data for approval for Base Station Radio, Locomotive/Cab Car Radio, Vehicular Mobile Radio, Portable Radio, and DED radio proposed by or before the 65 percent design submittal.

2. Submit for approval catalog cut-sheets and other manufacturer literature and manufacturer shop drawings describing all products proposed.

D. Installation Drawings: At least 60 days prior to the start of the installation of any item, submit a set of installation drawings for approval.

E. Test Plan And Procedures: At least 90 days prior to the start of testing, the Contractor shall submit a test plan and test procedures to the Engineer for approval. The testing shall thereafter proceed only after written approval of the plan and procedures by the Engineer.

F. Quality Assurance: Submit the resume of the Radio Communication Engineer for approval.

G. Operation and Maintenance Manuals, Training, And Spare Parts: Submit Operations and Maintenance (O&M) Manuals, a training plan, and a list of recommended Spare parts.

1. Submit O&M Manuals for all systems and devices provided under this Section. O&M Manual for the Radio System shall include electrical and mechanical specifications of all the components and sub-assemblies used to construct the system.

2. Training Plan: At least 60 days prior to training, submit Training Plan including Operation and Maintenance Manuals and a training outline for the approval. Submit resumes of the instructors.

3. Spare Parts List: Submit a list of recommended spare parts for Engineer approval at least 60 days prior to the start of training. Include manufacturers’ prices.

H. Test Equipment and Special Tools: Submit list at least 30 days prior to start of training. Submit list of test equipment and special tools required for the optimal maintenance of the radio system provided. List shall be complete with cost quotations.

I. Cut-Over Plans: Submit cut-over plans for approval.

J. As Built drawings shall be submitted no later than 30 days after system acceptance. To ensure accuracy of the “As-Builts”, a set of “red-line” as-constructed drawings shall be maintained at each site for which construction and installation work are in progress.

1.09 QUALITY ASSURANCE

A. Qualifications: Only qualified Radio Communication Engineer(s) shall be allowed for the performance of this work. Radio Communication Engineer shall be a professional Electrical Engineer licensed in the State of California, and shall have designed or integrated at least two similar projects in the last five years.
B. The Contractor shall include a Software Configuration Management document with all design documents to ensure that Caltrain maintains an accurate and documented record of all versions of “code plugs” and software deployed to support the ATCS network.

1.10 MAINTENANCE MATERIALS

A. Spare Parts: Furnish spare parts for Caltrain’s use in the following quantities. For the total quantity of each powered (active) device provided, furnish 20 percent (rounded to the next highest number) as spares. For the total quantity of each passive (un-powered) device provided, furnish 15 percent (rounded to the next highest number) as spares. These spare parts shall not be used by the Contractor in correction of defective work under the Guaranty of Work.

PART 2 – PRODUCTS

2.01 PRODUCTS

A. At a minimum, the selected radios and antennas shall meet the technical specifications listed in the following tables. Additionally Base Station, CP and DED sites shall be equipped with backup power as specified below:

<table>
<thead>
<tr>
<th>Table 2.1 Base Station Radio Technical Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPECIFICATION</td>
</tr>
<tr>
<td>Model</td>
</tr>
<tr>
<td>Operation</td>
</tr>
<tr>
<td>Squelch Gate</td>
</tr>
<tr>
<td>Power</td>
</tr>
<tr>
<td>Channel Spacing</td>
</tr>
<tr>
<td>Sensitivity (EIA 12 dB SINAD)</td>
</tr>
<tr>
<td>Selectivity (EIA 2-signal)</td>
</tr>
<tr>
<td># of Channels</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2.2 Locomotive/Cab Car Radio Technical Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPECIFICATION</td>
</tr>
<tr>
<td>Model</td>
</tr>
<tr>
<td>Operation</td>
</tr>
<tr>
<td>Squelch Gate</td>
</tr>
<tr>
<td>Power</td>
</tr>
<tr>
<td>Channel Spacing</td>
</tr>
<tr>
<td>Sensitivity (EIA 12 dB SINAD)</td>
</tr>
<tr>
<td>Selectivity (EIA 2-signal)</td>
</tr>
<tr>
<td>Amount of Channels</td>
</tr>
</tbody>
</table>
### Table 2.3 Mobile Radio Technical Specifications

<table>
<thead>
<tr>
<th>SPECIFICATION</th>
<th>DESCRIPTION</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>VHF, Analog, Conventional Mobile Radio</td>
<td></td>
</tr>
<tr>
<td>Operation</td>
<td>Simplex/Duplex</td>
<td></td>
</tr>
<tr>
<td>Squelch Gate</td>
<td>Carrier Only</td>
<td></td>
</tr>
<tr>
<td>Power</td>
<td>45 Watts, Adjustable</td>
<td></td>
</tr>
<tr>
<td>Channel Spacing</td>
<td>25/30 KHz, and 12.5 KHz</td>
<td>Refer to Contract Documents</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>-116 dBm</td>
<td></td>
</tr>
<tr>
<td>Selectivity</td>
<td>90 dB</td>
<td></td>
</tr>
<tr>
<td>Amount of Channels</td>
<td>&gt;90</td>
<td></td>
</tr>
</tbody>
</table>

### Table 2.4 Portable Radio Technical Specifications

<table>
<thead>
<tr>
<th>SPECIFICATION</th>
<th>DESCRIPTION</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>VHF, Analog, Conventional Portable Radio</td>
<td></td>
</tr>
<tr>
<td>Operation</td>
<td>Simplex/Duplex</td>
<td></td>
</tr>
<tr>
<td>Squelch Gate</td>
<td>Carrier Only</td>
<td></td>
</tr>
<tr>
<td>Power</td>
<td>5 Watts</td>
<td></td>
</tr>
<tr>
<td>Channel Spacing</td>
<td>25/30 KHz, and 12.5 KHz</td>
<td>Refer to Contract Documents</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>-116 dBm</td>
<td></td>
</tr>
<tr>
<td>Selectivity</td>
<td>90 dB</td>
<td></td>
</tr>
<tr>
<td>Amount of Channels</td>
<td>&gt;4</td>
<td></td>
</tr>
</tbody>
</table>

### Table 2.5 Dragging Equipment Detector Radio Technical Specifications

<table>
<thead>
<tr>
<th>SPECIFICATION</th>
<th>DESCRIPTION</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>Motorola VHF HT-750, Analog, Conventional Transmitter or Engineer approved equal</td>
<td></td>
</tr>
<tr>
<td>Operation</td>
<td>Transmit Only</td>
<td></td>
</tr>
<tr>
<td>Power</td>
<td>10 Watts, Adjustable</td>
<td></td>
</tr>
</tbody>
</table>

### Table 2.6 Antenna and Antenna Array Technical Specifications

<table>
<thead>
<tr>
<th>SPECIFICATION</th>
<th>DESCRIPTION</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pointing Azimuth</td>
<td>Directional, as required</td>
<td>BASE STATIONS AND DED</td>
</tr>
<tr>
<td>Frequency</td>
<td>159-162 MHz</td>
<td>ALL SITES</td>
</tr>
<tr>
<td>Gain</td>
<td>As needed</td>
<td>ALL SITES</td>
</tr>
<tr>
<td>Impedance</td>
<td>50 ohms</td>
<td>ALL SITES</td>
</tr>
<tr>
<td>Lightning Protection</td>
<td>DC Ground through support mast</td>
<td>ALL SITES</td>
</tr>
<tr>
<td>Beam-Tilt</td>
<td>As Needed</td>
<td>ALL SITES</td>
</tr>
<tr>
<td>Beam-width</td>
<td>As needed</td>
<td>ALL SITES</td>
</tr>
</tbody>
</table>
Table 2.7 Backup Power

<table>
<thead>
<tr>
<th>SPECIFICATION</th>
<th>DESCRIPTION</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backup Power</td>
<td>48 hours</td>
<td>BASE STATIONS SITES</td>
</tr>
<tr>
<td>Backup Power</td>
<td>8 hours</td>
<td>CONTROL POINTS</td>
</tr>
<tr>
<td>Backup Power</td>
<td>8 hours</td>
<td>DED</td>
</tr>
</tbody>
</table>

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install system in accordance with the approved shop and construction drawings and manufacturers written procedures.

B. Installers shall provide environmental protection of all outdoor installations: connectors shall have protective sleeves for weatherproofing, cabling and equipment shall be secured against strong winds, and electronics shall be mounted in NEMA 4 enclosures. Where antennas or other equipment is mounted on towers or poles, installations designs shall be stamped by a registered Civil/Structural Engineer, licensed in the State of California to ensure equipment does not exceed the maximum load of the tower or pole.

3.02 TESTING

A. Thoroughly test all installations and thoroughly document tests. Test radio system to ensure that the minimum RF coverage requirements specified herein are met.

B. Test Plan:

1. Prepare plan which shall, at a minimum, define the types of tests to be performed, the sequence of these tests, as well as any conditions that would require any changes to the amount, type or sequence of said tests. In addition, identify the personnel and protocol responsible for the execution, witnessing, and acceptance of these tests.

2. At a minimum, include in the test plan and develop detail test procedures for the following categories of tests:

   a. Factory Acceptance Tests (FAT)
   b. Miscellaneous Field Tests
   c. Radio Coverage Tests
   d. System-wide Field Acceptance Tests (SWFAT)

C. Perform all required Factory Acceptance Tests (FAT), Field Tests, (which may include ground resistance tests, battery capacity tests and site alarm tests), Radio Coverage tests and System-wide Field Acceptance Tests (SWFAT), in accordance with the approved Test Plan. All test plans and procedures involving the railroad
ROW, or affecting an active signal or communication system shall follow the Site Specific Work Plan (SSWP) process.

D. Perform Factory Acceptance Tests for all components, subsystems or subassemblies that are manufactured independent of other subsystems or subassemblies. Notify the Engineer when Factory Acceptance Tests are performed sufficiently in advance of tests to give the Engineer the opportunity to witness tests. The Engineer may, at his sole discretion, elect to waive some of these FATs.

E. Perform miscellaneous field tests on any component, subsystem or subassembly that is required to be put into service prior to the completion of the SWFAT. These may include ground resistance tests, battery capacity tests and site alarm tests.

F. Perform Radio Coverage testing for all portions of the ROW. Test coverage to/from trains moving along the ROW on the downlink paths, using a computer-controlled measurement and recording device that continuously monitors and records the RF signal levels that would be measured by a train radio as it travels the length of the ROW. Since the reverse process of measuring the uplink signal strength is considerably more difficult, the Contractor may utilize a combination of sample uplink signal strength measurements, along with a correlation, which shall be computed by the Contractor, between the measured downlink signal strength and the expected uplink signal strength from the same location pair.

Additionally, in order for measured signal strength to be used as the predictor of signal quality, the Contractor shall derive a correlation between the measured signal strength to be used as the pass/fail criterion and 20 dB SINAD. This derived mathematical relation shall also be supported by sample measurements of 20 dB SINAD and signal strength in 5% of the test locations to confirm the correlation. The Contractor shall prepare and submit the derived uplink/downlink correlation, as well as the derived 20 dB SINAD/signal strength correlation to the Engineer for approval at the same time that the test procedures are submitted for approval. The sample measurements shall be taken at the start of testing, and if necessary, the models tuned until the correct correlations are confirmed. Correlations between 20 dB SINAD and DAQ 3.4 or CM 4 will also be considered in lieu of signal strength. If the Contractor proposes to use such correlation analysis, submit it to the Engineer for review and approval.

G. Conduct System-wide Field Acceptance Testing (SWFAT) in all areas where the radio coverage or radio equipment interfaces to users or other subsystems. Conduct these tests only after the radio system is placed in its final configuration and interfaced to all other systems with which it is expected to interact during normal operations. The tests shall fully demonstrate the operation of all the radio sites, Base Stations, and equipment as a single system, capable of meeting all of the coverage, reliability and other specification parameters defined herein.

### 3.03 CUT-OVER

A. Prepare cut-over plans, where applicable. Prepare a cut-over plan for all installation work along the ROW as well as at remote Radio Base Station sites, irrespective of whether or not this work is scheduled for revenue or non-revenue hours. Plans shall clearly and thoroughly define the required sequence of activities, including staging, installation and testing of all materials and
subsystems, in such a way as to minimize interruption to the Owner’s revenue system and other railroad operations.

B. Execute approved cut-over plan.

3.04 TRAINING

A. Provide a training program for Caltrain and their Operating Railroad of Record personnel at least 4, but no earlier than 13 weeks, prior to the completion of the final acceptance testing. Training shall be tailored for Maintenance and Operations personnel, and training material specific to these two groups shall be designed and provided. Duration of training as well as the class size shall be as specified in the Contract Documents.

B. The following are the minimum required items in the course outline:

1. Prerequisite Mathematics
2. Prerequisite Background/Introductory material
3. Detailed System Description
4. System Tolerances
5. System Troubleshooting
6. As-Built Drawings of Radio System
7. Configuration Management plan

END OF SECTION
SECTION 19200
ATCS DATA RADIO NETWORK

PART 1 – GENERAL

1.01 DESCRIPTION

A. Section includes requirements for extension, upgrade, or retrofit of the existing ATCS Data Radio Network design and installation.

1.02 REFERENCE STANDARDS

A. Design and installation shall be in accordance with the applicable codes and regulations, including the following:
   1. National Electrical Code (NEC)
   2. AREMA C&S Manual
   3. CAL/OSHA standards
   4. California Public Utilities Commission (CPUC) Regulations
   5. State of California Electrical Safety Orders, Title 8, CAC
   6. Applicable Federal Communications Commission (FCC) regulations
   7. Motorola R56 Grounding Standard

1.03 EXISTING SYSTEM DESCRIPTION - GENERAL

A. The Advanced Train Control System (ATCS) is a radio communication network, including a network protocol that is used in support of the Centralized Traffic Control (CTC) system.

B. The ATCS is a network of Base Station radio and Control Point radio sites implementing a Non-Vital Supervisory Control System in support of all train movement along the Peninsula Corridor. This supervisory control system is implemented via a data radio network, which connects the Control Points to the computer workstations, servers and packet switches located within the Centralized Equipment Maintenance and Operations Facility (CEMOF).

C. The three major parts of the ATCS Data Radio System are the Base Station radio sites, the Control Point radio sites and the CCF (Central Control Facility) Head-end interface. The ATCS protocol is utilized for the data radio communication links between the Base Station sites and the network of Control Point radio sites, as well on the DS0 communication links between the Base Station sites and the CCF.

D. Two (2) ATCS frequency pairs are utilized to implement the network paths and network redundancy. The two frequency pairs are: ATCS channel 2, which is used at the Monument Peak and San Bruno Mountain Base Station sites, with full coverage overlap and redundancy for Control Points from CP Mayfield as the south limit to CP 4th street as the north limit. ATCS channel 5, which is used at
the Monument Peak and CEMOF Base Station sites, with full coverage overlap and redundancy for Control Points from CP Michael as the south limit and CP Mary as the north limit. CP Lick, receives coverage support only from the Monument Peak site, yet is a part of the ATCS network, because it is monitored, not controlled, by Caltrain.

E. ATCS communication Backhaul between base station sites and the “Office” is provisioned via a Caltrain-owned microwave radio network, with nodes at the Monument Peak ATCS base station site, San Bruno ATCS base station site, San Carlos Headquarters and CEMOF.

1.04 EXISTING SYSTEM DESCRIPTION - BASE STATION SITES

A. Caltrain railroad consists of approximately 78 miles of railroad tracks serving freight and passenger operations between San Francisco and Gilroy. A total of three Base Station sites are used to support all message transmissions between the CCF and these Control Points (CP). The three Base Station sites used are located at Monument Peak in Milpitas, San Bruno Mountain in Daly City and at the CEMOF in San Jose (all in California).

B. The three Base Stations (two on mountain tops and the single base station at CEMOF) are configured in pairs as redundant to each other, to the extent of their respective radio coverage footprints. The Monument Peak and San Bruno Mountain sites are each capable of providing ATCS data radio support to all of the North Dispatch Control Points along the Peninsula Corridor. Pairing the CEMOF site with the Monument Peak site provides full radio coverage and/or coverage redundancy for the South Dispatch Control Points from CP Michael at its south limit to CP Mayfield as its north limit.

Note, the design criteria for the addition of a Control Point to the ATCS Data Radio network is that it must receive full radio coverage, with an availability of at least 99 percent, from a minimum of two Base Station sites, otherwise it shall be supported using leased telephone circuits. CP Lick, which is the southernmost CP, is not “controlled” by Caltrain, but simply “monitored”, hence this coverage criterion does not apply to it.

1.05 EXISTING SYSTEM DESCRIPTION - CONTROL POINTS

A. Currently approximately 31 Control Points (circa 2011) are in operation, between CP Fourth Street to the north and CP Lick to the south, of which 27 are on the ATCS data radio network.

B. For ease of maintenance, the antenna towers used at each Control Point are a tilt down design capable of safely lowering the antenna and cable without damage.

1.06 EXISTING SYSTEM DESCRIPTION - CCF HEAD-END

A. The management of the ATCS network is performed at the CCF Head-end. A Dispatch Console, a Code Server and a Packet Switch are configured to manage the network. At the CCF, the dispatcher implements a route request by first inputting a control command into the Code Server. The Code Server decodes the command and passes another encoded message to the Packet Switches, which have the dual function of ensuring that the output protocol to the Base Station network is implementing the ATCS protocol (gateway function) as well as decide which Base Station site will be the most-likely-server for the Control Point being
commanded (router function). Caltrain uses a Code Server manufactured by DigiCon Incorporated. The DigiCon Code Server does not implement the ATCS protocol. Instead, a variety of other protocols are supported and implemented in the Caltrain system. This DigiCon system, replaced beginning 2012, by a new IP based dispatch console head-end provided by AIRINC, called AIM dispatch head-end console.

B. The Supervisory Control Systems (SCS)-128 protocol, developed by Safetran Systems (Invensys), is used for all direct, leased telephone line links between Control Points and the CCF, as well as for the links between the Base Station sites and the CCF.

C. The Genisys Protocol is also utilized. This protocol is used only for the direct, leased telephone line link between the major Control Point at Fourth Street and the CCF, and the leased line to CP Army. As Caltrain expands its data radio network, the use of the Genisys protocol, for the 4th Street site will be replaced with SCS-128. The Genisys at CP Army will be converted to ATCS. Further, in order to improve data radio throughput, the use of an ATCS protocol directly on the Digicon Code Server or AIRINC Front End Processor (FEP) shall be investigated. The Digicon Code Server is a rack-mounted computer, using a proprietary operating system developed by Digital Concepts Incorporated. It has the capability to support interfaces to several dispatch stations.

D. The CCF Packet Switches used in support of the ATCS data radio network are manufactured by Safetran Systems. They incorporate built-in hardware redundancy via the use of a dual packet-switch design in one box, one of which is redundant, and connected to the code server/FEP.

E. The Packet Switches shall convert all messages from the code server in SCS-128 protocol to the ATCS protocol. Likewise DS0 messages from the field Base Station sites, which are encoded with the ATCS protocol, shall be converted to SCS-128 before being routed to the Code Server.

F. The CCF Packet switches shall also monitor the inbound signal quality (RSSI) from each of the 28 Control Points to their respective Base Station sites, in order to determine which Base Station site received the strongest signal from the Control Point. This RSSI information shall be used by the Packet Switch(es) to determine, in real time, which Base Station site will be the most-likely server, and shall route the next message from the Code Server to this Base Station site. Note: the current RSSI result is not saved for general future routing of messages to Base Station sites, but is used in real time for routing only the next outbound message to the most-likely-server Base Station site.

1.07 FUNCTIONAL REQUIREMENTS - COMMUNICATION LINKS

A. Caltrain owns and operates licenses for two ATCS channels. The two ATCS Data Radio Channels shall be configured to provide full duplex Data Radio Operation between the CCF and all Control Points along the Corridor. From the CCF, the Data Radio messages shall be transmitted to each of the Base Station sites via the use of Microwave Radio links (with a reliability of 99.999 percent or better) or direct 4-wire 600 ohm cable (in the case of the CEMOF base station) or the use of carrier-leased 4-Wire telephone circuits as a backup.

B. The Data Radios shall utilize the specification compliant ATCS communication protocol for communication between the Control Points and the Base Station
Sites. The network can support the following interface options: HDLC LAPD, HDLC LAPB and/or TCP/IP. From the Base Station sites, the messages shall be transmitted to the Control Points along the Corridor via a pair of Multiple Addressing Scheme (MAS) ATCS frequencies licensed from the FCC, with a communications reliability of 99.0 percent or better, sufficient to ensure communications at 10 E-7 BER without FEC coding. A fade margin of 17dB shall be factored into the design to account for Rayleigh fading that will affect radio paths. The Base Station sites shall receive from 100 percent of the Control Points, likewise, with 99.0 percent communication reliability, providing 10 E-7 BER without FEC Coding.

C. The Communications back-haul serves to connect the CTC network and code servers, located at the CCF in the CEMOF in San Jose with the two mountain top ATCS Radio Base Station sites. Control requests and Signal indications are communicated between the CCF and the ATCS Radio Base Stations using this communications back-haul.

The existing voice radio communication backhaul uses a Caltrain-owned Microwave Radio network between the CCF and the following two ATCS Radio Base Station sites: Monument Peak and San Bruno Mountain. The communication backhaul between the ATCS Radio Base Station site co-located at the CEMOF facility is provisioned via a twisted-pair 4-wire circuit, less than 100 feet in length.

At the Monument Peak and San Bruno Mountain sites, the Caltrain has provisioned the infrastructure to support a two-wire data line backup, which is currently configured for cold-stand-by operation. Refer to Caltrain Design Criteria, Chapter 6, Train Control Communication for further details of the existing ATCS Radio communications back-haul.

### 1.08 FUNCTIONAL REQUIREMENTS - COMMUNICATION PROTOCOLS

A. The ATCS communications between the CCF (Code Server) and the Base Station sites shall be based on a polling scheme. Each Base Station site shall be assigned to a unique “code-line” on the Code Server, which shall poll each Base Station site in turn, in order to retrieve messages sent from the various Control Points.

B. The ATCS communication between the Base Station sites and the Control Points shall be based on a contention scheme. A pair of 900 MHz band ATCS frequencies configured for a Multiple-Address-Scheme is used to implement the channel.

### 1.09 FUNCTIONAL REQUIREMENTS - FREQUENCIES AND LICENSING

A. The following ATCS channels and frequencies are used currently, and additional ATCS pairs shall be licensed as required:

<table>
<thead>
<tr>
<th>ATCS CHANNEL</th>
<th>FREQUENCY</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>935.9375 MHz</td>
<td>Base Station Tx. Frequency</td>
</tr>
<tr>
<td>2</td>
<td>896.9375 MHz</td>
<td>Base Station Rx. Frequency</td>
</tr>
</tbody>
</table>
B. Under this scheme, each Control Point, which has a message to send to the CCF, will “contend” for the radio channel with all other Control Points. This will result in some RF-Network collisions, the amount of which shall be kept to a minimum in order to preserve the designed maximum speeds and minimum head-ways.

C. Data Radio Base Station repeaters shall employ GMSK direct FM configured for 12.5 KHz channel spacing. Base Station antennas shall be directional, high gain yagi antennas with the horizontal and vertical beam widths and orientation that would allow them to establish point to point radio links with each of the Control Points with the required communication reliability and signal quality. The Antennas used at Control Points shall be omni-directional, which allows for efficient expansion of the ATCS network. In special cases, a high-gain directional antenna may be required to maintain system design specifications at certain Control Point location(s).

D. The quantity of collisions is a direct function of the ratio of Control Points to Base Stations: the higher this ratio, the greater the number of collisions; the larger the number of collisions, the lower the data throughput of the ATCS network. Additionally the reliability of the RF links is another factor that aggravates data throughput. As communication reliability falls below 99 percent, the number of communication re-tries increases, resulting in a longer time required to send or receive a message.

E. The third factor affecting data throughput is the protocol conversion overhead. Currently there are four (4) protocol conversions required per message round-trip (two per direction).

F. The maximum railroad speeds and the minimum railroad head-ways are dependent on these design parameters. As the system expands, a thorough analysis of these parameters will be necessary to ensure reliable and efficient operations.

### 1.10 DESIGN REQUIREMENTS

A. Design extension, upgrade or retrofit of the ATCS Data Radio Network, as applicable. Design shall be in accordance with applicable FCC rules and regulations.

B. Design Prerequisites: Execute and submit design of the Radio System in four iterative parts: the 30 percent, 65 percent, 100 percent, and IFB/IFC.

C. SCADA Interfaces: Equip mountain top Base Station Radio sites with Alarm monitoring and remote control/command interfaces that shall permit the Dispatcher at the CCF to monitor Alarm conditions at each site, as well as remotely reboot any component of the Base Station that is micro-processor.
based. The Base Station shall be interfaced to a SCADA system provided by others. The SCADA system shall be capable of reporting to the existing Train Control server.

1. As a minimum, the following alarms shall be provisioned:
   a. Low/ Loss of RF Power
   b. High VSWR
   c. Loss of AC Power
   d. Loss of DC Power
   e. Rectifier failure
   f. High Temperature
   g. Door Open

2. Each alarm shall be activated via a dry contact relay pair, which shall be normally open.

D. Radio Coverage Simulations: Utilize computer simulations to predict the reliability of the various ATCS UHF radio links between the Base Station sites and Control Points. These computer simulations shall utilize terrain data with a resolution no worse than 30 meters. Use the NAD 83 or later geodetic datum. The radio communication links between all Base Stations and Control Points shall have a reliability of 99.0 percent or greater.

E. Intermodulation Studies: For all new installations with three or more transmit frequencies, or those with less than three transmit frequencies but more than two external adjacent frequencies (of power, measured internal to the new system, within 10 dB of the power of the transmit frequencies) that cannot be removed with notch filters, construct and execute an intermodulation study. This study shall examine all receiver intermodulation products created from the mixing of these transmit frequencies.

F. Structural Design: Provide structural design for new lattice, monopole or tilt-down towers, tower foundations, and civil structures associated with new installations required for the work of this Section. Design shall take into account specific soil types at each site. Drawings and calculations shall be signed and sealed by a professional engineer licensed in the State of California. Designs shall be based on the use of a geotechnical report prepared for the respective site(s) and shall include all calculations using maximum weights and wind loads supported by the towers.

1.11 SYSTEM AND EQUIPMENT UPGRADES

A. Caltrain is currently evaluating the following ATCS system and equipment upgrades:

1. ATCS to IP for all messages to/from Control Points resulting in an ATCS over IP message architecture.
2. A new IP based dispatch console/head-end to replace the obsolete Digicon Console and code servers. The AIRINC AIM dispatch head-end console and code servers will replace the existing Digicon Console and code servers in beginning 2012.

1.12 FUTURE SYSTEM ENHANCEMENTS

The following future railroad safety and passenger enhancements are currently planned. The existing CTC system shall be loosely interfaced to these systems and may share some site infrastructure/resources, such as Base Station sites.

A Positive Train Control (PTC)

PTC is a safety enhancement mandated by the Federal Government and is required to be operable for the Caltrain by 12/31/2015. The PTC safety enhancement shall be an overlay on top of the existing CTC system, which is currently implemented using the ATCS network. The following subsystems are required for PTC:

2. One 802.11x WLAN (where x = selected standard such as b, a, g, ne or e) and/or commercial cellular mode subsystems that shall be deployed to support PTC data uploads inside each of the designated Caltrain yards, terminals and lay-over sites.
3. Right-of-Way survey of existing GPS coverage that shall be used for navigational and TDMA timing purposes.
4. A bi-directional amplifier and combiner/multi-coupler interface to repeat the PTC 220 MHz radio communications traffic, to/from inside and TDMA timing information to the four (4) tunnels using the existing distribution antenna systems (radiating cable) already installed inside each tunnel.

B California High Speed Rail (CHSR)

CHSR is a Federal and State sponsored initiative that will interface to the Caltrain railroad, and as a result will interface to the existing CTC/ATCS system/network.

1.13 SUBMITTALS

A. Design Submittals: Submit design documents in four phases in accordance with an approved submittal schedule. Obtain the Engineer’s approval of each part before proceeding to more advanced parts.

1. 30 percent design document
2. 65 percent design document
3. 100 percent design document
4. Issued for Construction document
5. As Constructed (As-Built) document
The 65%, 100% IFB/IFC and As-Built design documents shall, at a minimum, include the following documents:

a. Radio Coverage Simulations

b. Intermodulation Studies

c. Grounding and Lightning Protection: In accordance with requirements indicated on the Contract Drawings, submit detailed drawings depicting the grounding configuration proposed for each radio site

d. Structural Design Calculations and Drawings

e. Radio “code plugs”

f. Configuration management documents

B. Obtain Engineer’s approval of any deviations from the specified design requirements. Submit request explaining the reasons for deviations and a description of the deviation itself for approval.

C. Product Data and Shop Drawings: Submit product data and manufacturer shop drawings at least 60 days prior to start of any installation.

1. Submit for approval catalog cut-sheets and other manufacturer literature and manufacturer shop drawings describing products proposed.

D. Installation Drawings: At least 60 days prior to the start of the installation of any item, submit a set of installation drawings for approval.

E. Test Plan And Procedures: At least ninety (90) days, prior to the start of testing, submit a test plan and test procedures to the Engineer for approval. The testing shall thereafter proceed only after written approval of the plan and procedures by the Engineer. All test plans and procedures involving the railroad ROW, or affecting an active signal or communication system shall follow the Site Specific Work Plan (SSWP) process.

F. Quality Assurance: Submit the resume of the Radio Communication Engineer for approval.

G. Operation and Maintenance Manuals, Training, And Spare Parts: Submit Operations and Maintenance (O&M) Manuals, a training plan, and a list of recommended Spare parts.

1. Submit O&M Manuals for all systems and devices provided under this Section. Operations and Maintenance Manual for the Radio System shall include electrical and mechanical specifications of all the components and sub-assemblies used to construct the system.

2. Training Plan: At least 60 days prior to training, submit Training Plan including Operation and Maintenance Manuals and a training outline for the approval. Submit resumes of the instructors.
3. **Spare Parts List:** Submit a list of recommended spare parts for approval at least 60 days prior to the start of training. Include manufacturers’ prices.

H. **Test Equipment and Special Tools:** Submit list at least 30 days prior to start of training. Submit list of test equipment and special tools required for the optimal maintenance of the radio system provided. List shall be complete with cost quotations.

I. **Cut-Over Plans:** Submit cut-over plans for approval.

J. As Built drawings shall be submitted no later than 30 days after system acceptance. To ensure accuracy of the “As-Builts,” a set of “red-line” as-constructed drawings shall be maintained at each site for which construction and installation work are in progress.

### 1.14 QUALITY ASSURANCE

A. **Qualifications:** Only qualified Radio Communication Engineer(s) shall be allowed for the performance of this work. Radio Communication Engineer shall be a professional Electrical Engineer licensed in the State of California, and shall have designed or integrated at least two similar projects in the last five years.

B. The Contractor shall include a Software Configuration Management document with all design documents to ensure that Caltrain maintains an accurate and documented record of all versions of “code plugs” and software deployed to support the ATCS network.

### 1.15 MAINTENANCE MATERIALS

A. **Spare Parts:** Furnish spare parts for Caltrain’s use in the following quantities. For the total quantity of each powered (active) device provided, furnish 20 percent (rounded to the next highest number) as spares. For the total quantity of each passive (un-powered) device provided, furnish 15 percent (rounded to the next highest number) as spares. These spare parts shall not be used by the Contractor in the correction of defective work under the Guaranty of Work.

### PART 2 – PRODUCTS

#### 2.01 GENERAL

A. Use the equipment identified herein in the design, extension, upgrade, or retrofit of the ATCS network.

#### 2.02 BASE STATION EQUIPMENT

A. These following specifications for the ATCS Data Radio Base Station equipment are based on the SAFETRAN BCP ATCS data radio transceiver. The Contractor may submit alternate BCP transceivers, manufactured by others, to the Engineer for consideration.
### TABLE 2.1 Base Station Data Radio Technical Specifications

<table>
<thead>
<tr>
<th>GENERAL:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>FCC Compliance</td>
<td>Parts 15, 90</td>
</tr>
<tr>
<td><strong>Transmitter</strong></td>
<td></td>
</tr>
<tr>
<td>RF Power Output</td>
<td>25-75W Adjustable</td>
</tr>
<tr>
<td>Duty Cycle</td>
<td>Continuous</td>
</tr>
<tr>
<td>Spurious Emissions</td>
<td>-90 dBc</td>
</tr>
<tr>
<td>Harmonic Emissions</td>
<td>-90 dBc</td>
</tr>
<tr>
<td>Audio Response</td>
<td>+1/-3 dB per TIA-603</td>
</tr>
<tr>
<td>Hum &amp; Noise</td>
<td>-45 dB per TIA-603</td>
</tr>
<tr>
<td>Frequency Spread</td>
<td>5 MHz</td>
</tr>
<tr>
<td>Frequency Stability</td>
<td>±0.1 ppm, -30°C to +60°C (-22°F to + 140°F)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RF Data Communication</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency Range</td>
<td>Transmit @ 935-940 MHz</td>
</tr>
<tr>
<td></td>
<td>Receiver @ 896-901 MHz</td>
</tr>
<tr>
<td>Number of Channels</td>
<td>1 (Synthesized, programmable) TX, 1 RX</td>
</tr>
<tr>
<td>Channel Spacing</td>
<td>12.5 kHz</td>
</tr>
<tr>
<td>Channel Resolution</td>
<td>12.5 kHz</td>
</tr>
<tr>
<td>Data Modulation</td>
<td>GMSK, Direct FM</td>
</tr>
<tr>
<td>RF Bit Rate</td>
<td>4800 bits/sec</td>
</tr>
<tr>
<td>Error Correction</td>
<td>Reed-Solomon (16,12) Forward</td>
</tr>
<tr>
<td></td>
<td>Error Correction (FEC) and 16 bit</td>
</tr>
<tr>
<td></td>
<td>Cyclical Redundancy Check (CRC)</td>
</tr>
<tr>
<td></td>
<td>per ATCS Spec. 200 Appendix L</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ground Network Port</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Port Type</td>
<td>Sync. / Async., EIA-232 with Configurable Ports</td>
</tr>
<tr>
<td></td>
<td>Modem Signaling</td>
</tr>
<tr>
<td>Baud Rate</td>
<td>Up to 2.048 Mbit/sec 9600 bit/sec typical</td>
</tr>
<tr>
<td>Data Link Protocol</td>
<td>HDLC Balanced</td>
</tr>
<tr>
<td></td>
<td>per ATCS Spec. 200, Appendix K;</td>
</tr>
<tr>
<td></td>
<td>HDLC Polled</td>
</tr>
</tbody>
</table>
### Receiver

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity 12 dB EIA SINAD</td>
<td>0.35 uV</td>
</tr>
<tr>
<td>20 dB Quieting</td>
<td>0.50 uV</td>
</tr>
<tr>
<td>Adjacent Channel Rejection</td>
<td>-75 dB</td>
</tr>
<tr>
<td>Intermodulation Rejection (EIA SINAD)</td>
<td>-75 dB</td>
</tr>
<tr>
<td>Spurious and Image Rejection</td>
<td>-90 dB</td>
</tr>
<tr>
<td>Audio Squelch Sensitivity</td>
<td>12 dB SINAD</td>
</tr>
<tr>
<td>Audio Response</td>
<td>+1/-3 dB per TIA-603</td>
</tr>
<tr>
<td>Hum &amp; Noise Ratio</td>
<td>-45 dB</td>
</tr>
<tr>
<td>Frequency Spread</td>
<td>5 MHz</td>
</tr>
<tr>
<td>Frequency Stability</td>
<td>+0.1 ppm, -30°C to + 60°C (-22°F to + 140°F)</td>
</tr>
</tbody>
</table>

### Diagnostic Service Port

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Port Type</td>
<td>Async. EIA-232</td>
</tr>
<tr>
<td>Baud Rate</td>
<td>19200 bit/sec typical</td>
</tr>
<tr>
<td>Data Link Protocol</td>
<td>ANSI, 8 Data bits</td>
</tr>
<tr>
<td></td>
<td>No Parity, 1 Stop bit</td>
</tr>
</tbody>
</table>

### Electrical Requirements

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC Input Voltage</td>
<td>120-240 VAC @ 50-60 Hz</td>
</tr>
<tr>
<td>AC Input Current</td>
<td>0.4A (Standby @ 117VAC)</td>
</tr>
<tr>
<td></td>
<td>1.8A (Tx@ 25W, @ 117VAC)</td>
</tr>
<tr>
<td></td>
<td>3.3A (Tx @ 75W, @ 117VAC)</td>
</tr>
<tr>
<td>AC Input Power</td>
<td>47W (Standby)</td>
</tr>
<tr>
<td></td>
<td>211W (Tx@25W)</td>
</tr>
<tr>
<td></td>
<td>390W (Tx@75W)</td>
</tr>
<tr>
<td>DC Input Voltage</td>
<td>26.5 VDC</td>
</tr>
<tr>
<td>DC Input Current</td>
<td>6A (Tx@25W)</td>
</tr>
<tr>
<td></td>
<td>11A (Tx@75W)</td>
</tr>
</tbody>
</table>

### TABLE 2.2 BASE STATION UHF Antenna Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>890-940 Mhz</td>
</tr>
<tr>
<td>Pointing Azimuth</td>
<td>Base Station: Directional</td>
</tr>
<tr>
<td>Control Points</td>
<td>Omni-directional</td>
</tr>
<tr>
<td>Bandwidth for 1.5 to 1 VSWR</td>
<td>50 Mhz</td>
</tr>
</tbody>
</table>
2.03 CONTROL POINT EQUIPMENT

A. Furnish either 80, 60 or 40 foot, Tilt-Down Towers, as determined by the design, from Western Towers or approved equal. Height of the tower shall be as indicated in the Contract Documents or as proposed by the Contractor and approved by the Engineer. Foundations for 80 foot towers shall be pre-built by tower manufacturer. Furnish padlock of size and type approved by the Engineer. Padlock shall be four (4) inch or larger padlock as manufactured by Master Lock or equal. Include the following at each tower:

1. Aluminum mast in order to raise the overall height of the Tilt-Down tower plus mast to height indicated in the Contract Documents. (Note, Antenna plus Aluminum mast shall have a combined weight no greater than 20 pounds)

2. A 900 MHz lightning arrester

B. Furnish the Mobile Communications Package (MCP) Radios from Safetran Systems (Invensys) or from GE/ Harmon or Engineer approved equal.

C. Provide the coaxial cable, CP Antennas, Ethernet Spread Spectrum radios (where required per the design), the 12Vdc batteries and chargers and other Data Radio products procured from the sources listed in Table 2.3 below or from an Engineer approved equal source.

D. Provide 7/8 inch coaxial cable transmission line complete with Type N connectors (Male to mate with N female on antenna and N Female for the other end of the 7/8” coaxial cable transmission line). Furnish a minimum of one spare connector of each type. Provide a minimum of two (2) weatherproofing/heat-shrinking kits.

### TABLE 2.3 Data Radio System Product (Equipment List)

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Equipment Description</th>
<th>Equipment Part No.</th>
<th>Manufacturer/Vendor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Spread Spectrum (Ethernet) radio</td>
<td>A53325</td>
<td>Safetran (Invensys)</td>
</tr>
<tr>
<td>2</td>
<td>WCP II ATCS Radio</td>
<td>9011-53411-0205</td>
<td>Safetran (Invensys)</td>
</tr>
<tr>
<td>3</td>
<td>Router</td>
<td>2811</td>
<td>Cisco Systems</td>
</tr>
<tr>
<td>4</td>
<td>Ethernet Switch</td>
<td>Part of Item No. 3</td>
<td>Cisco Systems</td>
</tr>
<tr>
<td>5</td>
<td>WAG</td>
<td>A53457</td>
<td>Safetran (Invensys)</td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td>Manufacturer/Model</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------</td>
<td>----------------------</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>UPS</td>
<td>APC SUA1500RM2U</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Batteries</td>
<td>SAFT ED 240</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Battery Charger</td>
<td>NRS ERB-C 12/201 C, ERB-C 12/401 C</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>DC/DC Converter</td>
<td>Part of #2 Safetran</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>2.4 GHz Lightning Arrestor</td>
<td>IS-MT50LN-MA Polyphaser/Tessco</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>900MHz Lightning Arrestor</td>
<td>DSXL-D-ME Polyphaser/Tessco</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>PLC</td>
<td>N/A Allen/Bradley</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Spread Spectrum 2.4 GHz Antenna</td>
<td>WISP24009PTNF Maxrad/Tessco</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>ATCS 900MHz Antenna</td>
<td>DBS86-Y Decibel Products/Tessco</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Coaxial Cables</td>
<td>LCFS114-50A Cellwave/Andrew</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Coaxial Cables</td>
<td>LCF78-50A Cellwave/Andrew</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>LCF12-50A Cellwave/Andrew</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Tilt-Down Antenna Mast &amp; Installation accessories</td>
<td>N/A Various</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Miscellaneous Accessories</td>
<td>N/A Various</td>
<td></td>
</tr>
</tbody>
</table>

**TABLE 2.4 Control Point Data Radio Technical Specifications**

<table>
<thead>
<tr>
<th><strong>General</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions</td>
<td>5 inches high by 10 inches wide by 10 inches long</td>
</tr>
<tr>
<td>Weight</td>
<td>16 lbs</td>
</tr>
<tr>
<td>FCC Compliance</td>
<td>Parts 15, 90</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Transmitter</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>RF Power Output</td>
<td>30W Normal</td>
</tr>
<tr>
<td>Duty Cycle</td>
<td>Per TIA-603</td>
</tr>
<tr>
<td>Spurious Emissions</td>
<td>-65 dBC</td>
</tr>
<tr>
<td>Harmonic Emissions</td>
<td>-65 dBC</td>
</tr>
<tr>
<td>Frequency Stability</td>
<td>1.5 ppm, -30°C to 60°C</td>
</tr>
<tr>
<td></td>
<td>(-22° to + 140°F)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>RF Data Communications</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency Range</td>
<td>Receive @ 935-941 MHz</td>
</tr>
<tr>
<td></td>
<td>Transit @ 896-902 MHz, Normal</td>
</tr>
<tr>
<td></td>
<td>Transmit @ 935-941 MHz, T/A Mode</td>
</tr>
<tr>
<td>Number of Channels</td>
<td>6 pairs (Synthesized, programmable)</td>
</tr>
<tr>
<td>Channel Spacing</td>
<td>12.5 kHz</td>
</tr>
<tr>
<td>Channel Resolution</td>
<td>12.5 kHz</td>
</tr>
<tr>
<td>Data Modulation</td>
<td>GMSK, Direct FM</td>
</tr>
</tbody>
</table>
### ATCS DATA RADIO NETWORK

**RF Bite Rate**
- 4800 bits/sec

**Error Correction**
- Reed-Solomon (16, 12) Forward
- Error Correction (FEC) and 16 bit
- Cyclic Redundancy Check (CRC)
- per ATCS Spec. 200. Appendix L

**RF Channel Access**
- Data “Busy-Bit” protocol
- per ATCS Spec. 200, Appendix I

#### Client Ports

<table>
<thead>
<tr>
<th>Types of Ports</th>
<th>3 software configurable interfaces</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2 Sync. / Async., EIA-422/EIA-232</td>
</tr>
<tr>
<td></td>
<td>1 Sync. / Async., EIA-422</td>
</tr>
</tbody>
</table>

**Baud Rate**
- 9600 bit/sec typical

**Data Link Protocol**
- HDLC Balanced
- (Sync. Or PPP Async.)
- Per ATCS Spec. 200, Appendix K
- HDLC Polled (Dial Backup)
- Others Available

**Alarm Inputs**
- 7 Total

### Receiver

- Sensitivity 12 dB EIA SINAD: 0.35 uV
- Selectivity: -70 dB
- Intermodulation Rejection (EIA SINAD): -65 dB
- Spurious and Image Rejection: -75 dB
- Frequency Stability: 1.5 ppm, -30° to + 60°C
  (-22°F to + 140°F)
- Input Impedance: 50 ohms

### Diagnostic Service Port

- Port Type: Async. EIA-RS-422
- Baud Rate: 19200 bit/sec typical
- Data Link Protocol: HDLC

### Electrical Requirements

- DC Input Voltage: 13.6 VDC, Negative Ground
- DC Input Current:
  - 3A (Rx)
  - 14A (Tx)
2.04 CCF HEAD-END EQUIPMENT

A. Due to the nature of the CCF Head-end interfaces, Caltrain will not allow equipment substitutions to the major CCF assemblies identified below, unless the Contractor can prove that the substitutions will not compromise the stability and reliability of the system. Generic network equipment such as switches and hubs can be replaced with COTS products.

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Equipment Description</th>
<th>Equipment Part No.</th>
<th>Manufacturer/ Vendor</th>
<th>Substitutions Allowed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Code / FEP Server</td>
<td>Various</td>
<td>AIRINC AIM</td>
<td>Disallowed</td>
</tr>
<tr>
<td>2</td>
<td>Packet Switch</td>
<td>Various</td>
<td>Safetran (invensys)</td>
<td>Disallowed</td>
</tr>
<tr>
<td>3</td>
<td>Dispatch Workstation</td>
<td>Various</td>
<td>AIRINC AIM</td>
<td>Disallowed</td>
</tr>
</tbody>
</table>

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install system in accordance with the approved shop and construction drawings and manufacturers written procedures.

B. Installers shall provide environmental protection of all outdoor installations: connectors shall have protective sleeves for weatherproofing, cabling and equipment shall be secured against strong winds, and electronics shall be mounted in NEMA 4 enclosures. Where antennas or other equipment is mounted on towers or poles, installations designs shall be stamped by a registered Civil Engineer, licensed in the State of California to ensure equipment does not exceed the maximum load of the tower or pole.

3.02 TILT-DOWN TOWER INSTALLATION

A. Install tilt down towers as the Antenna Tower at each CP in accordance with approved installation drawings, manufacturer’s instructions and design submittals. Follow the manufacturer’s written safety precautions for the installation and lowering of the tower. In particular, ensure that the path of the rotating tower arm is parallel to the track(s) as it spins about the pivot and is clear of overhead power lines and other obstacles. The Tilt-Down tower shall not be within 10 feet of the nearest rail, or any point above the tracks at any point during its range of motion or while in the full horizontal position.

B. Install foundations for 80 foot Tilt-Down towers per detailed instructions provided by the manufacturer. Install cast-in-place concrete foundations in accordance with approved submittals for 40 and 60 foot towers.

C. Ground the entire Tilt-Down tower and foundation assembly in accordance with the approved submittals.
D. Lock the pivot of the tilt down tower immediately after the erection of the tower with padlock. The Tilt-Down tower shall remain locked, until such time as the Owner takes possession of it and replaces this lock.

E. In the process of installing tower foundation and grounding system, cad-weld the ground wires to the steel foundation.

F. Utilize a trained installation technician to prepare and install coaxial cable transmission line connectors.

G. Ensure there is the correct Data cable to interface the VHLC to the data port of the MCP radio, and also the correct code plug.

3.03 TESTING

A. Thoroughly test all installations and thoroughly document tests. Test radio system to ensure that the minimum RF coverage requirements specified herein are met.

B. Test Plan:

1. Prepare a plan which shall, at a minimum, define the types of test to be performed, the sequence of these tests, as well as any conditions that would require any changes to the amount, type or sequence of said tests. In addition, identify the personnel and protocol responsible for the execution, witnessing, and acceptance of these tests. Include a sample of test data sheets.

2. At a minimum, include in the test plan and develop detail test procedures for the following categories of tests:
   a. Factory Acceptance Tests (FAT)
   b. Miscellaneous Field Tests
   c. Radio Coverage Tests
   d. System-wide Field Acceptance Tests (SWFAT)

C. Perform all required Factory Acceptance Tests (FAT), Field Tests, (which may include ground resistance tests, battery capacity tests and site alarm tests), Radio Coverage tests and System-wide Field Acceptance Tests (SWFAT), in accordance with the approved Test Plan.

D. Perform Factory Acceptance Tests for all components, subsystems or subassemblies that are manufactured independent of other subsystems or subassemblies. Notify the Engineer when Factory Acceptance Tests are performed sufficiently in advance of tests to give the Engineer the opportunity to witness tests. The Engineer may, at his sole discretion, elect to waive some of these FATs.

E. Perform miscellaneous field tests on any component, subsystem or subassembly that is required to be put into service prior to the completion of the SWFAT. These may include ground resistance tests, battery capacity tests and site alarm tests.
1. Prior to cutting the system over, conduct a Voltage Standing Wave Ratio (VSWR) sweep and an impedance test on the end-to-end connection of the three sections of coaxial antenna cable (less the lightning arrester) at new tilt-down tower installations.

F. Perform radio Link testing between all Base Station sites and the Control Points they serve. Individually test all links for the downlink as well as the uplink paths. Attach a computing device, configured to measure BER, at the end of each link under test in order to verify that they meet the minimum data error requirements.

G. Conduct Systemwide Field Acceptance Testing (SWFAT) in all areas where the radio coverage or radio equipment interfaces to users or other subsystems. Conduct these tests only after the radio system is placed in its final configuration and interfaced to all other systems with which it is expected to interact during normal operations. The tests shall fully demonstrate the operation of all the radio sites, Base Stations, and equipment as a single system, capable of meeting all of the coverage, reliability and other specification parameters defined herein.

3.04 CUT-OVER

A. Prepare a cut-over plan, where applicable. Plan shall clearly and thoroughly define the required sequence of activities, including staging, installation and testing of all materials and subsystems, in such a way as to minimize interruption to the Caltrain’s revenue system and other railroad operations.

B. Execute approved cut-over plan.

3.05 TRAINING

A. Provide a training program for Caltrain and their Operating Railroad of Record personnel at least four but no earlier than 13 weeks, prior to the completion of the final acceptance testing. Training shall be tailored for maintenance and Operations personnel, and training material specific to these two groups shall be designed and provided. Duration of training as well as the class size shall be as specified in the Contract Documents.

B. The following are the minimum required items in the course outline:

1. Prerequisite Mathematics
2. Prerequisite Background/Introductory material
3. Detailed System Description
4. System Tolerances
5. System Troubleshooting
6. As-Built Drawings of Radio System

END OF SECTION
SECTION 20110
BALLAST AND WALKWAY AGGREGATE

PART 1 – GENERAL

1.01 DESCRIPTION

A. Section includes specifications for furnishing and placing ballast and walkway aggregate. For the purpose of this Section ballast refers to ballast for main tracks and walkway aggregate for maintenance of way walkway. Obtain ballast only from the sources or quarries already approved by Owner.

1.02 REFERENCE STANDARDS


1. Chapter 1, Roadway and Ballast

B. American Society for Testing and Materials (ASTM International):

1. C29 Test Method for Bulk Density (Unit Weight) and Voids in Aggregate
2. C88 Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
3. C117 Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
4. C127 Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
7. C142 Test Method for Clay Lumps and Friable Particles in Aggregates
9. C702 Practice for Reducing Samples of Aggregate to Testing Size
10. D75 Practice for Sampling Aggregates
11. D3744 Test Method for Aggregate Durability Index
12. D4791 Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregates

C. California Public Utilities Commission (CPUC) General Orders:

1. 118 Construction, reconstruction and maintenance of walkways and control, of vegetation adjacent to railroad tracks

1.03 SUBMITTALS

A. Submit Certificates of Compliance for ballast and walkway aggregate certifying that the materials meet the requirements specified herein including laboratory test results accompanied by a written report from the testing lab. The testing shall not be older than 90 days and performed on samples taken from production stockpile.

B. Submit at least one 150-lb. ballast test sample.

C. Submit name and location of ballast source, production rates, and production logistics.

D. Submit detailed plans and descriptions for shipping, handling, and placing ballast.

1.04 DELIVERABLES

A. Submit a report confirming the readiness of the subgrade for ballast placement including as-built subgrade elevations and compaction test results.

B. Laboratory test results for all tests used in determining minimum property requirements of ballast.

1.05 QUALITY ASSURANCE

A. Refer to Section 01400, Quality Control and Assurance. Ballast is subject to inspection and testing by the Engineer at any time between quarry production and acceptance of track.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Load ballast at the quarry, transport, and unload directly on the track. Engineer may allow transportation by truck if the Contractor can ensure that the segregation, degradation, or contamination of the ballast would not occur as a result of trucking and placing.

PART 2 – PRODUCTS

2.01 MATERIAL PROPERTY REQUIREMENTS OF BALLAST/WALKWAY AGGREGATE

A. Ballast/walkway aggregate production and handling facilities shall conform to the AREMA Manual, Chapter 1, Section 2.5, Production and Handling.
B. Ballast/walkway aggregate shall be crushed stone broken by the crusher and have at least 2 broken surfaces: angular, rough-surfaced, clean and free of sand, loam, clay, flat, elongated, soft or disintegrated pieces, and other deleterious substances.

1. The Ballast/walkway aggregate shall conform to the property requirements shown in the following table.

**MINIMUM PROPERTY REQUIREMENTS**

**BALLAST/WALKWAY AGGREGATE**

<table>
<thead>
<tr>
<th>Property</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk specific gravity - Rock</td>
<td>2.75</td>
<td>--</td>
<td>ASTM C127</td>
</tr>
<tr>
<td>Degradation</td>
<td>--</td>
<td>20 %</td>
<td>ASTM C535/C131</td>
</tr>
<tr>
<td>Durability Test – Procedure A</td>
<td>65</td>
<td>--</td>
<td>ASTM D3744</td>
</tr>
<tr>
<td>Percent material passing No. 200 Sieve</td>
<td>--</td>
<td>1.0 %</td>
<td>ASTM C117</td>
</tr>
<tr>
<td>Absorption – Rock</td>
<td>--</td>
<td>1.0 %</td>
<td>ASTM C127</td>
</tr>
<tr>
<td>Clay lumps and friable particles</td>
<td>--</td>
<td>0.5 %</td>
<td>ASTM C142</td>
</tr>
<tr>
<td>Soundness - (Sodium Sulfate), 5 cycles</td>
<td>--</td>
<td>5 %</td>
<td>ASTM C88</td>
</tr>
<tr>
<td>Flat and/or elongated particles</td>
<td>--</td>
<td>5 %</td>
<td>ASTM D4791</td>
</tr>
</tbody>
</table>

C. Unacceptable ballast/walkway aggregate materials: Round rocks, boulders, cobbles or gravels.

D. Unacceptable ballast/walkway aggregate parent materials: Carbonates, sedimentary rock, alluvium, sandstone, limestone, and slag.

E. Obtain ballast/walkway aggregate material from one quarry source throughout the duration of the Contract.

2.02 GRADATION REQUIREMENTS OF BALLAST

1. Ballast (AREMA Size No. 4A) shall fall within the following gradation requirements:

<table>
<thead>
<tr>
<th>Nominal Sieve Size (Square Opening)</th>
<th>% Passing by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-1/2 inch</td>
<td>100</td>
</tr>
<tr>
<td>2 inch</td>
<td>90-100</td>
</tr>
<tr>
<td>1-1/2 inch</td>
<td>60-90</td>
</tr>
<tr>
<td>1 inch</td>
<td>10-35</td>
</tr>
<tr>
<td>3/4 inch</td>
<td>0-10</td>
</tr>
<tr>
<td>3/8 inch</td>
<td>0-3</td>
</tr>
<tr>
<td>No. 4</td>
<td>0-0.5</td>
</tr>
</tbody>
</table>
2. Walkway aggregate (AREMA Size No. 5) shall fall within the following gradation requirements:

<table>
<thead>
<tr>
<th>Nominal Sieve Size (Square Opening)</th>
<th>% Passing by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1/2 inch</td>
<td>100</td>
</tr>
<tr>
<td>1 inch</td>
<td>90-100</td>
</tr>
<tr>
<td>3/4 inch</td>
<td>40-75</td>
</tr>
<tr>
<td>1/2 inch</td>
<td>15-35</td>
</tr>
<tr>
<td>3/8 inch</td>
<td>0-15</td>
</tr>
<tr>
<td>No. 4</td>
<td>0-5</td>
</tr>
</tbody>
</table>

2.03 WASHING

A. Wash processed ballast and walkway aggregate to remove fine particle contamination as defined by the specifications prior to delivery.

PART 3 – EXECUTION

3.01 EXAMINATION AND CORRECTION OF SUBGRADE

A. Prior to placing ballast on track subgrade, perform a final check of the condition of the track subgrade as to line, grade, cross section, and compaction.

1. Verify that track subgrade or subballast does not vary more than 1/2 inch from the design elevations and the line cross sections.

2. Repair uneven or settled subgrade with aggregate base or material approved by the Engineer in accordance with the requirements of Section 02310, Aggregate Base Courses, and Section 02300, Earthwork.

3. Compact subgrade in accordance with the requirements of Section 02310, Aggregate Base Courses, and Section 02300, Earthwork.

4. Prior to the placement of ballast, submit a report listed under Deliverables herein confirming the readiness of the subgrade.

B. Do not place ballast on soft, muddy areas. Repair the unsuitable area for approval by the Engineer.

3.02 GENERAL

A. At any time ballast is found to not conform to these specifications, stop ballast operations until ballast that does not conform to these specifications is removed and replaced.

B. Remove and replace ballast that becomes contaminated with fines or other deleterious material with new ballast.

3.03 BALLAST DISTRIBUTION

A. Obtain Engineer’s approval of subgrade prior to distributing ballast.
B. Unload ballast directly from rail cars onto the track. Distribution by truck or loader is subject to the approval of the Engineer.

C. When distributing ballast, prevent forming of ruts that would impair proper drainage of the subgrade surface. Level and re-grade ruts to drain prior to placing ballast.

D. Unload ballast as close as possible to the point of use so to prevent unnecessary handling. Do not handle ballast more than two (2) times from the quarry to the track unless otherwise approved by the Engineer. Pick up excess ballast and ballast that is mixed with soil or fouled during distribution and replace with new ballast.

E. Place ballast to the lines and grades as shown on the Contract Drawings.

F. Salvaged excess or fouled ballast shall not be used as backfill, bedding or as fill materials unless otherwise approved by the Engineer.

3.04 WALKWAY AGGREGATE DISTRIBUTION

A. Distribute walkway aggregate and place in areas of walkways in track and special trackwork as required by CPUC General Order 118 and in other areas as shown on the Contract Drawings and as described in Section 20500, Special Trackwork. Also place walkway aggregate around non-track underdrains and other areas as shown on the Contract Drawings.

B. Place walkway aggregate only after ballast on main track has been completely surfaced, tamped, and dressed. Do not mix walkway aggregate with ballast for purposes of tamping of track structure.

C. Place the walkway aggregate only after subgrade and backfill have been completely compacted and cleared of debris.

3.05 QUALITY CONTROL AND TESTING

A. Refer to Section 01400, Quality Control and Assurance. Testing shall be performed by an approved Inspection and Testing Agency retained by the Contractor.

B. Sample and test ballast material, during construction to ensure continued conformance with the requirements of this Section. The laboratory shall transmit test results directly to the Engineer with copies to the Contractor.

C. Perform gradation tests ASTM C136 and C117 at least once every 500 tons, and perform tests in Table 1 of this Section no less than every 5,000 tons. Take ballast samples at the quarry, in stockpiles, in track, and at the Engineer’s discretion.

D. Ballast Samples:
1. Perform gradation tests plus all of the tests specified herein on at least five (5) separate ballast samples at the quarry for the first 1,000 tons produced.

2. Test all samples of ballast material for conformance with ASTM D75. Sample sizes shall be sufficient to provide the minimum sample sizes required by the designated test procedures. Reduce test samples from field samples in conformance with ASTM C702.

3. If the ballast consistently fails the gradation test for excess materials passing the No. 4 or No. 200 sieves, fully wash the ballast at the quarry. Consistent failure means three (3) or more failures per 500 tons sampled.

E. Gradation Test:


F. Other Tests:

1. Determine bulk specific gravity and absorption in conformance with ASTM C127.

2. Determine percentage of clay lumps and friable particles in conformance with ASTM C142.


5. Perform durability test in conformance with ASTM D3744, Procedure A.


G. Materials Not Meeting Specified Requirements: In the event any individual samples fail to meet the gradation or material requirements specified herein, the Engineer may suspend placement of the ballast and require immediate corrective action be taken to restore the specified gradation and material requirements, prior to resuming ballast placement.

END OF SECTION
SECTION 20120
TRACK APPURTENANCES AND OTHER TRACK MATERIAL

PART 1 – GENERAL

1.01 DESCRIPTION
A. Section includes specifications for other track materials (OTM) for concrete and timber ties. OTM includes rail fastening systems, screw spikes, track bolts, nuts, spring washers, tie plates, tie hole plugging material, rail anchors, standard toeless joint bars, compromise joint bars, and insulated joints.

1.02 GENERAL
A. Section 01005, Contractor’s Personnel and Equipment: Includes general requirements and submittals regarding railroad construction equipment used for work of this Section, including adzing equipment.

1.03 REFERENCE STANDARDS
A. American Railway Engineering and Maintenance of Way Association (AREMA):
B. American Society for Testing and Materials (ASTM International):
   1. A325 Specifications for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
   2. F436 Specification for Hardened Steel Washers
C. Caltrain Standard Drawings

1.04 DEFINITIONS
A. Tie Plate: Plate which has a rail seat, either flat or canted, double shoulder parallel to the rail it supports, and with holes for spikes or other fasteners. The bottom of the tie plate is usually flat, but may be ribbed or of other design.
B. Resilient Fastening System: Rail fastening system consisting of clips, insulators and pad on tie plate to fasten rail to ties.
C. Rail Anchor: Device which clamps to base of rail and bears against side of cross-tie (timber tie) to restrain longitudinal movement of rail.
D. Standard Joint Bar: Device used to connect the abutting end of contiguous rails of the same cross section.
E. Compromise Joint Bar: Joint bar used to connect contiguous rails of different cross section.
F. Insulated Rail Joint: Pre-fabricated or field-fabricated joint used to inhibit the flow of electric current between contiguous rails.

1.05 SUBMITTALS

A. Submit plan showing details for installation of OTM. Include manufacturer’s installation instructions, where applicable.

B. Submit Certificates of Compliance for all OTM. Include material qualification test reports for materials, components, and assemblies.

C. If field fabricated boned insulated joints approved by the Engineer, submit the insulated rail joint installation procedures at least 30 days prior to beginning joint installation work. Include, at a minimum, the following items for insulated rail joints:
   1. Contractor performing the field fabrication is certified by the supplier.
   2. Care and storage of materials
   3. Date of glue manufacture
   4. Glue shelf life
   5. Rail end preparation
   6. Weather and temperature restrictions
   7. Mixing and application of glue
   8. Installation of insulated joint bar and pin bolts
   9. Curing restrictions
   10. Detection of glue bond failures

D. Submit product data for kegs proposed for shipping screw spikes.

E. Submit samples of track materials, if requested by the Engineer

1.06 QUALITY ASSURANCE

A. Perform material qualification testing for all materials, components, and assemblies.

1.07 DELIVERY

A. Deliver screw spikes to the work site in Engineer approved containers (kegs).
1.08 EXTRA MATERIALS

A. Any excess materials that are property of the Owner shall be packaged as specified and hauled to stockpile area designated by the Engineer.

1. Place excess new spikes in containers.
2. Palletize and band excess tie plates.
3. Place the excess rail anchors in nylon sacks on pallets.

PART 2 – PRODUCTS

2.01 TIE PLATES

A. Tie plates shall conform to the requirements as indicated in Caltrain Standard Drawings.

B. Tie plates for use with elastic fasteners shall be standard 7-3/4 inches by 16 inches in accordance with Caltrain Standard Drawings.

2.02 TRACK SPIKES

A. Screw spikes shall be new 15/16 inch by 6 inches straight shank screw spikes with a minimum tensile strength of 73,000 psi. Head shall be hot forged and centered relative to the shank in accordance with Caltrain Standard Drawings.

B. Stamp screw spikes with manufacturer’s identification and date of manufacture (month and year).

2.03 RAIL ANCHORS

A. Rail anchors shall be Channeloc-type rail anchors manufactured by Chemtron True Temper or Engineer approved equal.

B. Rail anchors shall be sized to conform to the rail section used.

C. Rail anchors shall conform to the AREMA Manual, Chapter 5, Part 7, Section 7.1, “Specifications for Rail Anchors.”

2.04 TRACK BOLTS, NUTS AND SPRING WASHERS

A. Track bolts and nuts shall conform to the dimensions specified in the AREMA Manual, Chapter 4, Part 3, Section 3.3, Rail Drillings, Bar Punching, and Bolts.

B. Track bolts and nuts shall conform to the requirements of the AREMA Manual, Chapter 4, Part 3, Section 3.5, Specifications for Heat-Treated Carbon-Steel Track Bolts and Carbon-Steel Nuts.

C. Spring Washers shall conform to the requirements of the AREMA Manual, Chapter 4, Part 3, Section 3.6, Specifications for Spring Washers.
2.05 RESILIENT FASTENING SYSTEM

A. Furnish Pandrol E-2055 clip type or equal elastic fastening systems for use on timber switch ties.

B. Furnish modified Pandrol E-2063 or E-2063B clips, painted yellow, for insulated joint locations.

2.06 STANDARD AND COMPROMISE JOINT BARS

A. Standard 36-inch toeless joint bars shall be 6-hole bars, and shall be of the size, shape, and punch necessary to fit the rail sizes, conforming to the requirements in Caltrain Standard Drawings.

B. Compromise joint bars shall be of the size, shape, and punch necessary to fit the rail sizes and sections being joined in conformance with Caltrain Standard Drawings.

C. Compromise joint bars shall conform to the requirements of the AREMA Manual, Chapter 4, Part 3, Section 3.4, Specifications for Quenched Carbon-Steel Joint Bars, Microalloyed Joint Bars, and Forged Compromise Joint Bars.

D. Furnish only factory designed and produced (forged or cast) compromise joint bars for joining rails of different sizes or sections.

E. Make all permanent connections between different sizes of rail by using forged taper rails or compromise field welds.

2.07 INSULATED RAIL JOINTS

A. Furnish pre-fabricated insulated joints unless otherwise noted or approved by the Engineer. Where noted, furnish field fabricated bonded insulated rail joints.

B. Furnish insulated rail joints of the epoxy-bonded type as manufactured by Allegheny Rail Products, Co., American Track Systems, Inc., Portec Rail Products, Inc., Railway Bonded insulated joints, or Engineer approved equal, in accordance with the following:

1. Joint Components: Furnish insulated joints complete with bars, end posts, bushing, washers, pin bolts, collars, washers and adhesives as recommended by the manufacturer for final installation.

2. Furnish new, smooth, straight bars providing full face contact, conforming to the applicable rail section, and fabricated from micro alloyed steel or quenched carbon-steel as specified in AREMA, Specification for Quenched Carbon Steel Joint Bars. The toe of the joint bar shall properly fit against the web of the rail. When elastically fastened, the joint bar shall provide adequate clearance to maintain electrical isolation.
3. Provide pin bolts of ASTM A325 structural steel furnished with the appropriate collar. Provide flat circular hardened steel washers in accordance with ASTM F436.

4. Bolt hole size shall be in accordance with the bonded insulated joint manufacturer’s recommendation. If bolt hole diameter is larger than 1-3/16 inches, place ASTM A325 hardened washers between the joint bars and the nut.

C. Insulating paint for use in conjunction with insulated joints: As recommended by the insulated joint manufacturer and approved by the Engineer.

2.08 TIE PLUGS
A. Tie hole plugging material shall be SpikeFast by Willamette Valley Company, or Engineer approved equal.

2.09 SUPERELEVATION TAGS
A. Furnish metal superelevation tags manufactured from 16-gauge aluminum in accordance with Caltrain Standard Drawings. Stamp tags in 1/4-inch increments from zero to maximum superelevation.


2. Adhesive for Securing Tags to Concrete Ties must be approved by the Engineer.

PART 3 - EXECUTION

3.01 TIE PLATES
A. Install tie plates as specified in Section 20400, Track Construction.

B. Adze existing ties to receive new ties plates, prior to installing new rail and turnouts. Tie adzing shall only be of sufficient depth to allow for a full level seat for the new tie plate and remove indentation of old tie plate. The width of adze shall be the full width of the tie, and the length of the adze shall extend beyond the width of the tie plate seat by a minimum of one half inch of each side. Install the tie hole plugging material in all open spike holes prior to adzing.

C. Use only approved power operated adzing equipment for adzing, with an approved back-up adzer available on site at all times.

3.02 TRACK SPIKES
A. Install track spikes as specified in Section 20400, Track Construction.

3.03 RAIL ANCHORS
A. Install rail anchors in accordance with the requirements of Section 20400, Track Construction.
3.04 BOLTS, NUTS, AND SPRING WASHERS

A. The various rail drillings and joint bar punches require various lengths and diameters of bolt assemblies. Determine the number of bolt assemblies of each size requires. In general, all bolt diameters shall be the largest possible for a given rail drilling and joint bar punching. Bolts shall be the proper length for the joint bar to allow at least one full bolt thread to extend past the outside of the nut. Spring washers and nuts shall be of a size sufficient to ensure that the spring washer develops its full reactive force and does not jam into the joint bar hole.

B. Install bolt assemblies in accordance with the requirements of Section 20400, Track Construction.

3.05 RESILIENT FASTENERS

A. Install resilient fasteners in accordance with the requirements of Section 20400, Track Construction and Section 20500, Special Trackwork.

3.06 STANDARD AND COMPROMISE JOINT BARS

A. Install compromise joint bars in accordance with the requirements of Section 20400, Track Construction.

B. Temporary bolted joints will be permitted for the Contractor's convenience to facilitate construction, unless otherwise directed by the Engineer. The use of bolted joints during the construction of CWR track shall be kept to a minimum, and all bolted joints shall be replaced by field welds prior to de-stressing.

3.07 INSULATED RAIL JOINTS

A. Install pre-fabricated and field-fabricated insulated joints at locations shown on the Contract Drawings and in conformance with the manufacturer's recommended procedures. Install two insulated joints, on opposite rails at each callout on the Contract Drawing, with a stagger of two (2) cross-tie spacings, unless otherwise noted.

B. Notify the Engineer 24 hours in advance of installation of insulated joints at each location.

C. Test all insulated joints after installation into track in accordance with the requirements in Section 18600, Signal Systems Testing.

1. Remove, replace, and retest any bonded insulated joint that fails the electrical test in track. Obtain Engineer's approval of insulated joint replacement procedure prior to making replacement.

D. Properly fasten the elastic fasteners to secure the insulated joints in place using Pandrol clips specified herein for resilient fastening at insulated joints. Use overdrive protectors when using E-2063B clips to obtain proper installation. Do not overdrive the clips.
E. Apply insulating paint to the circumference of the rail head and post after assembly and curing of bonded insulated joint adhesive. Apply the insulating paint as a stripe centered on the end post, one inch plus or minus 1/4 inch wide.

3.08 RAIL BONDS

A. Bond all jointed rail, both permanent and temporary, in accordance with the requirements in Section 18400, Rail Bonding.

3.09 TIE PLUGS

A. Plug all spike holes where spikes have been removed in existing ties that are to remain in track and that are to receive new tie plates or new spikes. Use tie hole plugging materials.

B. Install tie hole plugging material in accordance with the manufacturer’s instructions. Top of tie hole plugging material shall be flush with top of hole.

2.10 SUPERELEVATION TAGS

A. Install tags in accordance with the Contract Documents and Caltrain Standard Plans. At concrete ties, follow adhesive manufacturer’s instructions.

END OF SECTION
SECTION 20130
TIMBER CROSSTIES AND SWITCH TIES

PART 1 - GENERAL

1.01 DESCRIPTION

A. Section includes specifications for timber crossties and switch ties in track construction, including special trackwork. Installation of timber ties is specified in Sections 20400, Track Construction, and 20500, Special Trackwork.

1.02 REFERENCE STANDARDS

A. Caltrain Standard Drawings

B. American Railway Engineering and Maintenance of Way Association (AREMA):

C. American Wood-Preservers’ Association (AWPA):
   1. P1 Standard for Creosote Preservative
   2. P2 Standard for Creosote-Petroleum Oil Solution
   3. P4 Standard for Petroleum Oil for Blending with Creosote

D. West Coast Lumber Inspection Bureau (WCLIB):
   1. Standard Grading Rules, Number 17 (WCLIB Rules)

1.03 SUBMITTALS

A. Certificates of Compliance for preservative treatment, ascertaining conformance with the approved preservative within one week of completion of testing.

B. Inspection Certificate from the WCLIB for grading compliance prior to application of preservative treatment.

C. Certificate of Compliance from manufacturer or suppliers certifying that the materials delivered to the site are in compliance with the requirements of this Section. Include supporting test results.

1.04 STORAGE AND HANDLING

A. Handle ties carefully to avoid damage in accordance with the AREMA Manual, Chapter 30, Part 3, Section 3.5, The Handling of Ties from the Tree Into the Track.
B. Stockpile new ties only where directed by the Engineer. Band ties with minimum of two bands in 12-tie bundle, and stack to a maximum of 3 bundles high, with slating between layers of bundles, and at a maximum height of 12 feet.

C. Choose storage locations with proper security, access, and drainage. Stack ties tightly and off the ground for storage to prevent them from becoming warped or damaged.

PART 2 - PRODUCTS

2.01 GENERAL

A. Ties shall be new oak or mixed hardwood with kerf mark to indicate heart wood side.

B. Timber crossties and switch ties shall have a cross-section of 7 by 9 inches, subject to the following:

1. Standard crossties shall be 7-inch, No 1 grade, 9 feet 0 inches long.

2. Transition/grade crossing crossties shall be 7-inch, No 1 grade, 10 feet 0 inches long.

3. Switch ties shall be full length, measuring full thickness and width throughout. Ties up to 1 inch wane or less will be inspected on an individual basis. Ties with more than 1 inch wane will be rejected. Ties with thickness and width more than 1/8 inch thinner or narrower than the specified size will be rejected.

4. Head block switch ties for manual throw turnouts shall be 8 by 12 inches.

5. Head block switch ties for power operated turnouts shall be 8 by 10 inches.

C. Do not use industrial grade crossties.

D. Any special timber ties for open-deck bridges shall be as specified and as shown in the Contract Documents.

2.02 TIMBER REQUIREMENTS AND BASIS OF REJECTION

A. General: Ties shall be fabricated from sound, straight, live timber, free from any defects that may impair their strength or durability, such as bark, splits, shakes, large or numerous holes or knots, pitch seams, pitch rings or other imperfections.

1. Ties with any type of decay or insect damage are not acceptable.

B. Except as specified in this Section, only those imperfections that are within the limits of the AREMA Manual will be allowed.
C. Rejection of ties for holes and knots: Ties with holes and knots (as defined below) between 20 and 40 inches from its middle will be rejected. Ties with these defects outside the rail bearing area may be rejected at the discretion of the Engineer.

1. Large hole: More than 1/2 inch in diameter and 3 inches in depth within, or more than 1/4 of the width of the surface on which it appears, and 3 inches deep outside, the sections of the tie between 20 inches and 40 inches from its middle.

2. Numerous holes: Any number of holes equaling a large hole in a damaging effect.

3. Large knot: One whose average diameter exceeds 1/4 the width of the surface on which it appears.

4. Numerous knots: Any number which, in total, equals a large knot in damaging effect.

D. Shakes which are more than 1/3 the width of the tie will be allowed provided it does not extend nearer than 1 inch to any surface.

E. Except in woods with interlocking grain, ties with a slant grain in excess of 1 in 15 will be rejected.

F. A check is a separation of the wood due to seasoning which appears on one surface only. Do not count the end as a surface. Ties with continuous checks whose depth in a fully seasoned or treated tie is greater than 1/4 the thickness and longer than 1/2 the length of the tie will be rejected.

2.03 TIE FABRICATION REQUIREMENTS

A. Ties shall be well sawed on all four sides and cut square at the end to the full dimensions specified. Straight and opposite faces shall be true and parallel.

B. Crossties and switch ties which comply with the following shall be considered straight:

1. Horizontally when it is concave or convex no more than 1 inch.

2. Vertically when it is concave or convex no more than 1/2 inch.

C. A tie will not be considered well sawn when its surfaces are cut into with scar marks more than 1/2 inch deep or when its surfaces are not even.

D. The top and bottom of a crosstie or switch tie shall be considered parallel if any difference in the thickness at the sides or ends does not exceed 1/2 inch.

2.04 END PLATES

A. All crossties and switch ties shall be end plated on both ends.
2.05 SEASONING

A. Crossties shall be seasoned in accordance with AREMA Manual, Chapter 30, Part 3, Section 3.5, The Handling of Ties from the Tree into the Track, and Section 3.6, Wood Preserving.

B. Pre-boring and dapping of crossties and switch ties shall be done prior to treatment to minimize splitting when driving spikes and provide preservative penetration around the spike holes. The boring pattern shall conform to the spiking pattern shown on the Caltrain Standard Drawings. Field boring of switch ties will be permitted if the hole is provided a method of preservative treatment approved in advance by the Engineer.

C. Bore from the top surface of the tie; bore shall not penetrate the bottom surface.

2.06 INCISING

A. Incise crossties and switch ties on all four sides in the pattern specified in the AREMA Manual, Chapter 30, Part 3, Section 3.7, Specifications for Treatment.

2.07 PRESERVATIVE

A. Preservative shall be in accordance with AWPA P3. Petroleum for blending with creosote shall comply with the AWPA P4.

B. Preservative applied to switch ties shall conform to AWPA P1.

C. Pressure treat ties in accordance with the empty cell process with a 50/50 to 40/60 creosote/petroleum base to a minimum retention of 7 pounds per cubic foot of wood, or to refusal retention.

D. Creosote-petroleum treatment solution shall be per AREMA Manual, Chapter 30, Part 3, Section 3.7.2, Treatment, and Section 3.7.4, Preservatives.

E. Apply the preservative only after the ties have a moisture content of 40 percent or less.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Prior to installation, perform a final visual inspection of the ties to ensure all ties to be installed are bored, branded, incised, and without defects.

3.02 INSTALLATION

A. Install ties in accordance with Sections 20400, Track Construction, 20500, Special Trackwork, and 20300, Crosstie Replacement, as applicable.

END OF SECTION
SECTION 20140

CONCRETE CROSSTIES AND RAIL FASTENER ASSEMBLIES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Section includes specifications for furnishing and installing new prestressed, pretensioned monoblock concrete crossties and rail fastener assemblies for use with 136 RE rail.

B. The concrete crossties (standard crossties and grade crossing ties) shall be as shown on the Caltrain Standard Drawings, and as specified in this Section.

C. The concrete crossties shall be compatible to the specified rail fastener assemblies.

D. Crossties for grade crossings shall accommodate precast concrete crossing panels specified in Section 20600, Concrete Grade Crossings.

1.2 REFERENCE STANDARDS

A. American Railway Engineering and Maintenance-of Way Association (AREMA):


B. American Society for Testing and Materials (ASTM International):

1. A536 Specification for Ductile Iron Castings
2. A881 Specification for Steel Wire, Deformed, Stress-Relieved or Low-Relaxation for Prestressed Concrete Railroad Ties
3. C31 Practice for Making and Curing Concrete Test Specimens in the Field
4. C33 Specification for Concrete Aggregates
5. C39 Test Method for Compressive Strength of Cylindrical Concrete Specimens
6. C78 Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
8. C150 Specification for Portland Cement
9. C172 Standard Practice for Sampling Freshly Mixed Concrete
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<td>10.</td>
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<td>Specification for Air-Entraining Admixtures for Concrete</td>
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<td>26.</td>
<td>D4066</td>
<td>Standard Classification System for Nylon Injection and Extrusion Materials (PA)</td>
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C. American Concrete Institute (ACI):

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<tr>
<td>A.</td>
<td>211.1</td>
<td>Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete</td>
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<td>B.</td>
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<td>C.</td>
<td>301-10</td>
<td>Specifications for Structural Concrete</td>
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</table>
D. Precast/Prestressed Concrete Institute (PCI):
   1. MNL 116 Manual for Quality Control for Plants and Production of Structural Precast and Prestressed Concrete Products

E. American Association of State Highway and Transportation Officials (AASHTO):
   1. T26 Method of Test for Quality of Water to be Used in Concrete

1.3 SUBMITTALS

A. The following submittals to the Engineer are in addition to the requirements in Section 01300, Submittals and Deliverables.

B. Within 30 days of Notice to Proceed, prior to concrete crosstie and rail fastener assembly qualification testing:
   1. Letter with supporting documentation stating that the crosstie manufacturer meets or exceeds the requirements per 1.5 of this Section.
   2. Rail fastener manufacturer’s approval of rail fastener application in the tie manufacture.
   3. Shop drawings for each type of crosstie including all information necessary for fabrication. Include plan, elevation and cross section with prestressing wires, rail fastener assemblies, and embedded items. Show dimensions, details, tolerances, finishes, concrete strength, and material specifications. Indicate part numbers.
   4. Letter from the rail fastener assembly manufacturer stating that the concrete crosstie manufacturer’s shop drawings and processes are compatible with the rail fastener assemblies.
   5. 3 samples each of the complete rail fastener assemblies, including embedded shoulders, rail clips, tie pads and insulators.

C. Within 45 days of Notice to Proceed:
   1. Concrete mix design with certified concrete and concrete components qualification test results.
   2. Manufacturer’s Test Program Plan. The Plan shall, at a minimum, conform to the requirements of this Section and shall provide sufficient detail of the manufacturer’s quality assurance program.

D. Within 7 Days after Completion of Testing and Inspection:
   1. Certified concrete tie and rail fastener assembly qualification test results prior to crosstie and rail fastener assembly production and after approval of the shop drawings.
2. Certified rail fastener assembly and concrete tie production test results, certified tie pad production test results, and certified material test reports prior to shipping the concrete ties and rail fastener assemblies.

E. At least 30 days prior to shipment, submit method of handling, loading, shipping, unloading and stacking concrete crossties, including working drawings showing the concrete crossties stacking arrangement.

1.4 DELIVERABLES

A. Certificate of Compliance one day after each shipment of concrete crossties. The Certificate shall state that the accompanying shipment of concrete ties fully complies with all the requirements specified in this Section.

B. Inventory records of concrete ties shipped at the time of each shipment.

C. Cement mill certificates.

1.5 MANUFACTURER QUALIFICATIONS

A. Concrete Tie Manufacture’s Qualifications:

1. A minimum of 5 years experience, in one location, of the large scale manufacture of pretensioned prestressed concrete crossties by the long line process with 5 to 8 lines per bed.

2. The plants shall be certified under the PCI Plant Certification Program.

3. Has supplied concrete crossties to a Class 1 Freight or Commuter Railroad within the last 5 years.

4. The Certificate of Qualification as the concrete crosstie supplier. Owner-approved manufacturers include CXT, Rocla, and KSA.

B. Rail Fastener Assembly Manufacture’s Qualifications:

1. A minimum of five years experience, in one location, of the large scale manufacture of rail fastener assembly for use in pretensioned prestressed concrete crossties.

2. Has supplied the rail fastener assemblies used on concrete crossties of a Class 1 Freight or Commuter Railroad within the last 5 years.

3. Owner-approved manufacturers include Pandrol.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Handle all ties such that to prevent damage (such as chipping, spalling, cracking, etc.) during loading, shipping, unloading and stockpiling. Do not drop, bang, scrap, or skid ties. Use only lifting devices appropriate for handling ties.
B. Securely brace ties for transportation to prevent any movement that could cause damage. Stack ties in upright position, separated uniformly with wooden spacer blocks (align with the rail seat area) to clear fastener shoulder inserts. Do not load ties higher than 6 layers.

C. Package rail fastener assembly parts separately and in waterproof containers to prevent damage during shipment and to facilitate handling.

D. Store ties to prevent unnecessary additional handling until the final distribution. Store ties in separate stacks segregated according to type of tie. Provide the necessary supports and spacers so that the ties will not contact the ground.

E. Replace concrete ties and rail fastener assemblies damaged during loading, shipping, unloading, and storage.

1.7 WARRANTY

A. Guarantee all items against defective materials, construction, or workmanship for a period of eight (8) years from the date of the ties and associated fastener assemblies have been installed on the ground and accepted, except when a longer guarantee is provided by the supplier or manufacturer.

1.8 SPARE PARTS

A. Furnish and deliver as Owner spares each of the following, separately packaged and clearly marked “SPARE PARTS”

1. For every 5000 cross ties:
   a. 100 fast clips (galvanized) including insulators
   b. 50 sidepost insulators
   c. 50 tie pads

2. For each grade crossing:
   a. 10 e clips (galvanized)

PART 2 - PRODUCTS

2.1 CONCRETE CROSSTIE DESIGN CRITERIA

A. Fabrication Dimensions and Tolerances:

1. Track Gage: The concrete tie and fasteners shall hold track gage to plus or minus 1/16 inch. The centerline of the tie shall be within 1/2 inch of the centerline of the track gage.

2. Differential Tilt of Rail Seats: The differential tilt in the direction parallel to the rail of one rail seat to the other rail seat shall not exceed 1/16 inch over the width of the tie.

3. Concrete Cover for Prestressing wires: 3/4 inch minimum cover
4. Prestressing wires shall be 5.32 mm minimum diameter, conforming to ASTM A881, Grade 260

5. Surface Finish: Heavy concentrations of surface voids or evidence of improper mixing, vibrating, or curing are not acceptable.

### 2.2 CONCRETE DESIGN CRITERIA

A. Concrete Mix Design, in accordance with ACI
   1. Qualify concrete mix design based on tests on trial batches, which shall show that concrete mix achieves the specified strengths and properties, including shrinkage and permeability.
   2. Submit a new mix design to qualify the mix if any constituents of the concrete are changed during cross tie production.

B. Cement: ASTM C150 Type III low alkali (less than 0.60 percent alkali content)

C. Flexural Strength, tested in accordance with ASTM
   1. Minimum 28-Day Flexural Strength: 750 psi
   2. Test one beam for every 2,000 ties for the first 6,000 ties produced

### 2.3 RAIL FASTENER ASSEMBLY DESIGN CRITERIA

A. General:
   1. The fasteners shall be of threadless design. To ensure compatibility among all components of the rail fastener assemblies and compatibility to the ties, they shall be manufactured by a single manufacturer.
   2. Note that the specified Pandrol fasteners and corresponding part numbers comply with the requirements in this Section. The specified part number may be different due to subsequent production change by Pandrol. The fasteners proposed for replacement shall meet or exceed the specified fasteners, and shall be as recommended, in writing, by the Pandrol, and submitted for the Engineer’s approval.

B. Rail Tie Pads (tie pads): Tie pads shall be Pandrol 7085WB, 6.5 mm thick, Poly complying with the following requirements:
   1. Minimize abrasion of the rail seat area, reduce impacts and vibration effects on the track structure and provide electrical insulation of the rail.
   2. Provide a positive means of preventing movement of the pad parallel to the rail. The pad thickness shall be 6.5mm, a width to extend around the shoulder to lock it in place.
   3. Manufactured from natural rubber or thermoplastics which provide the required chemical and physical properties to resist effects of temperature ranging from minus 20 degrees F to plus 160 degrees F, as
well as oxidation, water, alkali, salt, petroleum products, synthetic lubricants, and sunlight. Manufacture pads of first quality, new ingredients, processed and cured in accordance with accepted standard industry practice. Oil-extended rubber, reclaimed rubber, or rubber containing wax is not acceptable.

C. Rail Clips: The clips shall be Pandrol Fastclip 1601 (for standard crossties), galvanized and Pandrol E-clip 2055 (for grade crossing ties), galvanized complying for requirements for ease of installation and maintenance. The clips shall be adaptable to track laying machine. They shall be one-piece elastic, heat treated, alloy spring steel forced and quenched to achieve the holding power. Spring-wedged clips are not acceptable.

D. Insulators: Insulators shall be Pandrol 7695 (toe insulators) and 7692 (post insulators), covering the full widths of the shoulders, complying with the following requirements:

1. Provide electrical isolation, reduce abrasion, and transfer dynamic loading from the rail to the rail clip to prevent relative motion in any direction.

2. Two (2) insulators for each rail fastener assembly, one on each side of each rail. They shall insulate the rail clip from direct contact with the rail, and also insulate the rail from the shoulder inserts.

3. 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.

4. Keys shall be provided between the insulators and the fastener hardware to prevent relative motion in any direction.

5. Shall be made of materials which provide the required electrical, chemical and physical properties to resist dynamic loading, oxidation, water, alkali, salt, petroleum products, synthetic lubricants, and sunlight through a temperature range of minus 20 degrees F and plus 160 degrees F. Recycled material is not acceptable.

6. Insulator material shall be injection molded nylon conforming to ASTM D4066, Group 1, Class 2, Grade 4, ultra-violet stabilized through the heat stabilizer.

7. Insulators shall be protected against oxidative embrittlement by inclusion of a non-conductive ultraviolet stabilizer which will not diminish the electrical insulation properties of the insulators.

E. Embedded Shoulders: Embedded shoulders shall be twin-stem Pandrol 9086, not directly anchored to the pretensioned wires, complying with the following requirements:

1. Provide and maintain proper position and alignment of the rail, rail clip, insulators, tie pad and running rail base. The shoulders shall be of
ragged stem design to maximize the surface area and pull out resistance.

2. Made of ductile cast iron conforming to ASTM A536 Grades 60-40-18, or 65-45-12.

2.4 PRODUCTION

A. Prestressing Wires

1. Placement and Spacing: Place and space prestressing wires in accordance with the AREMA Manual, Chapter 30, Concrete Ties, Section 4.3 - Tie Dimensions, Configuration and Weight.

2. Supports: Accurately place and support prestressing wires before concrete is placed. Secure the prestressing wires against displacement greater than the permitted tolerances.

3. Prestressing wires: Inspect for proper surface condition. Prestressing wires shall be free of release agents or other substances.

B. Concrete Curing: Cure in accordance with the AREMA Manual for Railway Engineering, Chapter 30, Concrete Ties, Section 4.2 - Material, Article 1.2.2.5 – Curing.

2.5 SOURCE QUALITY CONTROL - GENERAL

A. Perform the testing required in this Section for the concrete crossties. Submit test results to the Engineer for review and approval.

B. Previous qualification tests performed on nearly identical concrete crossties produced for a Class I Freight or Commuter Railroad within the last 5 years may be acceptable in lieu of performing the required qualification testing.

C. Do not proceed with the production of the concrete ties until the shop drawings, concrete mix design, and qualification test result submittals have been reviewed and approved by the Engineer.

2.6 SHOP INSPECTION BY THE ENGINEER

A. Provide the Engineer written notice for inspection at least 30 days in advance of the initial in-shop inspection and 10 days in advance for subsequent in-shop inspections. Do not prepare materials for shipment before the Engineer has either inspected the materials or waived inspection.

B. After material has been delivered and unloaded, conduct an inspection and issue a report to the Engineer.
PART 3 - EXECUTION

3.01 CONCRETE TIE INSTALLATION

A. Prior to commencement of the crosstie installation, perform a final visual inspection of each tie to ensure all ties and their fastener assemblies are free of defects or damage and equipped with rail fastening assembly.

B. Install concrete ties in accordance with Section 20400, Track Construction, and related provisions.

END OF SECTION
SECTION 20150
RAIL

PART 1 - GENERAL

1.01 DESCRIPTION
A. Section includes specifications for Contractor-furnished 136 RE Continuously Welded Rail (CWR) and Owner-furnished CWR and jointed rails. Rail installation is specified in Section 20400, Track Construction.

1.02 REFERENCE STANDARDS
A. American Railway Engineering and Maintenance of Way Association (AREMA):
   2. Portfolio of Trackwork Plans (Plans)
B. American Association of Railroads (AAR):
   1. Specification for Quality Assurance M-1003

1.03 SUBMITTALS
A. Rail Material Schedule: Within 30 days of receipt of Notice to Proceed, and prior to the delivery of the rail to site, submit a complete schedule of all Contractor-furnished rail materials proposed for installation, source of the rail, and product information including rail section, length, and date rolled.
B. Product Data: Submit the following product data for rail:
   1. Manufacturer’s Catalog Data
   2. New Rail Product Analysis
   3. Rail Ultrasonic Test Report
C. Submit Certificate of Compliance that the rail furnished meets all requirements set forth in this Section.
D. Storage Plan: Submit a storage plan for each storage area where Contractor-furnished rail is proposed to be stored or stockpiled. Include sufficient detail to demonstrate that efficient handling and security provisions will be provided, that supporting soils will not be overloaded, and that materials will not be overstressed due to bending or shear.

1.04 DELIVERABLES
A. Quality Control Program (QCP): Submit rail manufacturer’s quality control program.
1.05 QUALITY ASSURANCE

A. Manufacturer’s Quality Control Program (QCP) shall be in accordance with the AAR M-1003 or Engineer approved equivalent quality control program.

B. Comply with AREMA Portfolio of Trackwork Plans.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Manufacturer’s Quality Control Program (QCP) shall be in accordance with the AAR M-1003 or Engineer approved equivalent quality control program.

B. Handle rail with roller, tongs or other methods that will not result in damage to the rail. Do not drop rail on uneven surfaces nor leave it unevenly supported.

C. Move CWR on rollers, buggies or other means to fully support it. Do not drag along the ground or across crossties.

D. Store rail in a designated site under the direction of the Engineer if not used for construction within 6 months of delivery.

PART 2 - PRODUCTS

2.01 GENERAL

A. Refer to Section 01600, Materials, for general requirements for Owner-furnished materials and for list of Owner-furnished materials, as applicable.

2.02 136 RE CONTINUOUS WELDED RAIL (CWR)

A. Furnish all rail, except as noted.

B. Contractor-furnished CWR shall be new 136 RE, intermediate strength, control cooled or vacuum treated carbon steel tee rail meeting AREMA Manual, Chapter 4, Section 2.1, Specifications for Steel Rails. Contractor-furnished CWR shall have been rolled within the year prior to shipment.

C. Deep head hardened rail in accordance with AREMA Manual, Internal Hardness of High-Strength Rail.

D. If the Contractor-furnished CWR are in sections instead of strings, CWR shall be manufactured on-site by welding rail sections in nominal 80 ft length into 1440 ft strings, or as specified in the Contract Documents.

2.03 OWNER-FURNISHED 136 RE CWR

A. If noted in the Contract Documents, the Owner will furnish strings of CWR of various lengths for installation at locations indicated in the Contract Drawings. Haul Owner-furnished rail from the storage locations. Haul back any surplus to storage area designated by the Engineer.

B. Re-ley existing CWR as indicated in the Contract Drawings.
2.04 OWNER-FURNISHED JOINTED RAIL

A. If noted in the Contract Documents, the Owner will furnish second hand jointed rail of varying sections in nominal 39 ft lengths at locations indicated on the Contract Drawings. Haul Owner-furnished jointed rail from the storage locations. Crop and weld the sections in required strings of CWR. Haul Owner-furnished surplus jointed rail back to storage area designated by the Engineer.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Prior to installation, perform visual inspection for presence of any defects in rail being installed including rail furnished by the Owner. Inspect rail as it is being installed.

B. Notify the Engineer of any suspected defects in any rail. Remove rail that is damaged or defective, including wear and corrosion, and clearly mark and place it by the rail bed. Communicate to the Engineer and Contractor’s employees whichever means the Contractor uses to mark defective rail.

3.02 INSTALLATION, CUTTING AND DRILLING OF RAIL, AND REMOVAL OF DEFECTIVE RAIL

A. Install rail as specified in Section 20400, Track Construction.

B. Cut and drill rail as specified in Section 20400, Track Construction.

C. Replace rail which has been installed but which is found to be defective, including isolated defects, as specified in Section 20400, Track Construction.

END OF SECTION
SECTION 20200
TRACK REMOVAL AND SALVAGE

PART 1 – GENERAL

1.01 DESCRIPTION
A. Section includes specifications for salvage and removal of existing track, special trackwork, and other track materials (OTM).
B. The work of this Section may require signal support and testing if removal of existing track involved signal equipment and components.

1.02 REFERENCES
A. American Railway Engineering and Maintenance of Way Association (AREMA):

1.03 SYSTEM DESCRIPTION
A. Perform work on this Section in accordance with applicable provisions of the AREMA Manual.
B. Engineer has the right to review and inspect all records and reports for track material salvage and removal at anytime between commencement and completion of the Work.

1.04 SUBMITTALS
A. Submit proposed salvage and removal methods and schedule, including personnel and equipment; schedule shall be consistent with SSWP specified in Section 01011, Work Planning.
B. Submit product data for marking paint.
C. Submit completed Track Material Inventory forms for all salvaged and removed materials except ballast. See Attachment 20010-A, found at the end of this Section.
   1. Include completed inventory forms for turnout components including ties. Utilize forms similar to the attached form, as required and accepted by the Engineer.

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 spray marking paint or a good quality paint marker as approved by the Engineer.

PART 3 – EXECUTION

3.01 VERIFICATION

A. Prior to commencement of removal and salvage, verify the removal and salvage quantities and storage locations.

3.02 SALVAGE AND REMOVAL OF TRACK MATERIALS

A. Salvage timber ties that Engineer determines to be in good condition, otherwise remove.

B. Salvage turnouts as indicated in the Contract Drawings.

C. Salvage joint bars, tie plates, bolts, nuts and washers (OTM), along with salvaged trackwork.

3.03 SALVAGE OF CWR TRACK

A. Salvage existing continuous welded rail (CWR) as indicated on Contract Drawings for track construction. Reuse where indicated; if reuse is not required, rail may be cut to manageable lengths and haul to storage area and stockpile as specified herein or as required by the Engineer.

B. Handle rail by roller tongs or other methods that will not result in damage to the rail. Do not drop rail on uneven surfaces nor leave them unevenly supported.

C. Move CWR on rollers. Do not drag along the ground or across crossties.

D. Do not cut salvaged CWR. Cutting of CWR is permitted only for fitting within limits of track construction. Use only rail saw or abrasive rail cutting wheel to cut CWR. Other methods for cutting rail will not be accepted. Cuts shall be square and clean.

E. A single handling hole may be drilled in the ends of CWR. Drill hole at 9 inches or 15 inches from the end of the rail to suit joint bar hole spacing. Remove hole prior to installation of CWR. Drilling and cutting rail as described in Section 20400, Track Construction, under Drilling and Cutting of Rail.

F. Remove ties, tie plates and other OTM not suitable for reuse as determined by the Engineer.

3.04 SALVAGING TRACK IN PANELS

A. In areas of existing CWR, the Contractor will be required to temporarily replace the CWR with owner-furnished 39 feet long jointed rail. The jointed rail shall be installed with squared joints in order to remove the track in panels. The removed CWR shall be handled in accordance with Caltrain Standard Specifications, so as to prevent...
damage to the rail. Existing CWR will generally be reused unless otherwise indicated in the Contract Drawings or directed by Engineer. CWR shall not be cut unless authorized by Engineer.

B. In areas of existing jointed rail, which is staggered, the Contractor will be required to square up the rail joints in order to remove the track in panels. This will require cutting and moving of the rail on one side of the track.

1. Do not torch cut rail or holes. Rail sections less than 15 feet in length are not allowed.

2. Rail joints must be bolted with at least 4 bolts, 2 per rail end. Broken bolts must be replaced when found, and all bolts must be kept tight allowing no vertical rail movement in the joints.

3. All trackwork done as required to remove existing track in panels shall be performed in accordance with Caltrain Standard Specifications.

5. Do not reuse existing rail anchors. Install new rail anchors on the jointed rail based on the anchoring pattern specified in Caltrain Standard Drawings. Prior to panel removal, install two (2) anchors per tie to the shoulder and joint ties with full bearing against the side of tie. Do not overdrive, as this may fracture or spread the metal, resulting in less holding power. Replace any rail anchor that is fractured or spread.

3.05 CLEANING OF TRACK MATERIALS

A. Sufficiently clean and then inspect track materials, except ballast, designated for salvage or reuse to ensure that no damage or significant corrosion exists.

B. Clean rail and joint bars by hand or mechanical means to remove dirt, and sort and haul them to the storage area indicated on the Contract Drawings or designated by the Engineer.

3.06 STORAGE AND HANDLING OF SALVAGED TRACK MATERIALS

A. Prevent damage to salvaged materials during salvage operation, handling, and storage.

B. Properly stack or contain salvaged track materials, in a neat fashion at the storage area designated by the Engineer.

C. Where specifically required in the Contract Documents or when required by the Engineer, clean and set salvaged continuously welded rail (CWR) and OTM adjacent to track. Requirements for storage of salvaged track materials shall apply.

D. Rail: Segregate salvaged jointed rail by rail section and length. Support bottom layer of rail on crossties evenly spaced. Locate rail piles in well drained sites with base of rail separated from ground surface. Separate each layer by at least three 2 x 4 inch wood strips evenly spaced for each 39 feet of rail. Stack rail in pyramid form with each tier of rail to be offset inward by one half the width of the rail base. Stacks shall be maximum height of 4 feet and maximum width of 15 feet at the base or as
directed by the Engineer. Stack rail with the heads up and with the rail ends square and even. Locate rail stacks in areas safely accessible by forklifts, cranes with rail tongs, and other equipment.

E. Turnouts: Disassemble, clean, palletize, box, place in drums salvaged turnouts, securely to prevent loss and damage during transport and storage. Clearly mark the contents of each individual package with a securely attached, weatherproof label.

F. Joint Bars: Sort joint bars by rail section and joint bar length, and stack on pallets. Steel band each pallet for forklift handling.

G. Tie Plates: Sort by size (length and rail base width), stack, and band on pallets for forklift handling.

H. Nuts, Bolts, and Washers: Sort and store in nylon sacks and on pallets.

I. Timber Ties, General: Stack crossties neatly and securely in bundles of 12 (3 ties high, 4 ties wide), band with three 1-1/4 inch bands, and space evenly for forklift handling. Plug all spike holes with tie plugs. Stack to a maximum of 3 bundles high and stockpile at the storage area shown on the Contract Drawings or where designated by the Engineer.

J. The maximum weight of any pallet with any material shall be 1,500 pounds.

3.07 REMOVAL OF TRACK MATERIALS

A. Where track and track materials are designated on the Contract Drawings or specified in this Section to be removed, remove from the work site and dispose of in accordance with the Contract documents.

ATTACHMENT Follows
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<tr>
<th>Item No.</th>
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<th>Location Removed</th>
<th>Date Removed</th>
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**Inventory of Materials Salvaged, Stored, Reused, and Removed**

END OF ATTACHMENT
SECTION 20300
CROSSTIE REPLACEMENT

PART 1 - GENERAL

1.01 DESCRIPTION
A. Section includes specifications for production timber crosstie replacement and spot timber crosstie replacement.

1.02 GENERAL
A. Section 01005, Contractor’s Personnel and Equipment: Includes general requirements and submittals regarding railroad construction equipment used for work of this Section.

1.03 REFERENCES
A. Caltrain Standard Drawings
B. American Railway Engineering and Maintenance of Way Association (AREMA):

1.04 DEFINITIONS
A. Production crosstie replacement generally refers to work areas of 500 track feet or longer, where rate of tie replacement consists of replacing an average of 1000 crossties per mile of track, between the limits indicated on the Contract Drawings, and as required by the Engineer. The actual rate may vary, plus or minus 200 ties per mile of track. No tie replacement will be required through the limits of at-grade vehicular or pedestrian crossings.
B. Spot tie replacement refers to localized replacement of one or more crossties in a specific area, generally less than 500 track feet in length.

1.05 SYSTEM DESCRIPTION
A. Perform work on this Section in accordance with applicable provisions of the AREMA Manual.

1.06 SUBMITTALS
A. Submit diagrams showing location and function of each person and each piece of equipment in the tie gang.
B. Submit plan and schedule for removal of existing ties, installation of new ties, and handling of all ties. This submittal shall be consistent with plans and schedules of Sections 01011, Work Planning, and 01310, Schedules.
1.07 DELIVERABLES

A. For production crosstie replacement work, submit an as-built track alignment report with tabulation of the vertical and horizontal positions of the prework and final track alignments.

B. For spot tie replacement work, submit a summary report of work performed, numbers and locations of the ties replaced, and level of ballast renewal.

PART 2 - PRODUCTS

2.01 CONTRACTOR-FURNISHED MATERIALS

A. Furnish ties, spikes, and superelevation tags compatible to each of the existing track and as specified in the Contract Documents.

B. Refer to Section 20130, Timber Crossties and Switch Ties, for timber ties replacement work.

C. Refer to Section 20110, Ballast and Walkway Aggregate, for ballast for crosstie replacement work.

PART 3 - EXECUTION

3.01 INSPECTION

A. Prior to commencement of the crosstie replacement work, inspect and verify areas indicated on Contract Drawings, marked in the field, or as required by the Engineer for crosstie replacement.

3.02 GENERAL

A. Replace defective ties as marked in the quantities identified in the Contract Documents and within the Contract limits.

B. Perform work in such manner to best utilize time allowed under the available working time limits.

C. Perform work in accordance with applicable parts of Section 20400, Track Construction, except as modified or amended herein.

3.03 PRODUCTION CROSSTIE REPLACEMENT

A. Refer to Section 01011, Work Planning. For production ties, assign work crew and equipment capable of installing a minimum of 800 ties per 6-hour work window with four (4) trains per hour passing on the adjacent track under a Form B.

B. Remove existing crossties without excessively splintering them. Dispose of these crossties including associated debris in accordance with GP 7.16, Disposal of Material Outside of the Work Site. Do not raise or hump the track more than...
one (1) inch when removing ties. Remove debris from crosstie renewal prior to surfacing operations.

C. Remove and dispose of existing cut spikes and rail anchors.

D. Reuse existing tie plates with the following exception: Worn, bent or cracked plates and plates less than 14-inch long shall be replaced with new plates. Position plates so that the batter of plate will cant rail to gauge side and be centered over the width of the tie to obtain proper bearing of rail. Ensure that outside (field side) shoulders of tie plates have full bearing against base of rail. Set spikes with a self propelled driver/setter machine.

E. Center tie plates over the width of the tie, except that the plate shall be positioned up to 1/2 inch off-center if necessary to avoid spiking into an existing tie split.

F. Use the standard spiking pattern in the Caltrain Standard Drawings. Keep respiking of new timber ties to a minimum. Replace ties that have been excessively respiked, as determined by the Engineer, or ties that have been respiked due to the Contractor’s carelessness.

G. Replace 50% of existing anchors with new ones. Install anchors tight against the tie.

H. When replacing crossties with resilient fastening system, reinstall resilient fasteners in accordance with the requirements of Section 20400, Track Construction.

I. Place new crossties square to the line of rail spaced on 19 1/2 inch centers. Crosstie position at joints shall result in a “suspended joint”, with new ties spaced so that center of the space between ties will coincide with center of joint bars.

J. Prior to completing work for the day, line and tamp all newly installed crossties with a production/switch tamper. Replenish ballast as necessary with new mainline ballast. This initial tamping pass shall result in ties being held securely, and provide a solid, balanced bearing on the ballast.

K. Upon completion of a continuous segment not to exceed one mile of crosstie replacement, perform a final line, stabilize, and surface and dress of the track to eliminate all localized humping or surface irregularities. Final line, stabilize, surface, and dress in accordance with Section 20400, Track Construction.

L. Install superelevation tags on completed ballasted track in accordance with Caltrain Standard Drawings.

### 3.04 SPOT CROSSTIE REPLACEMENT

A. Perform spot crosstie replacement in accordance with criteria given for production crosstie replacement.
B. Excavate the tie cribs and ends so that the old ties can be removed and new ties installed without jacking the rails, or otherwise distorting or "humping" the track.

C. Repair any track that is distorted or humped, as a result of the Contractor’s operation.

D. Install rail anchors in accordance with Caltrain Standard Drawings.

E. Spot tie replacement includes powered hand-machine tamping and dressing of track.

3.05 FIELD QUALITY CONTROL

A. After completion of spot tie replacement, perform inspection on post-work track condition. The crosstie replacement work is not accepted as complete until the Engineer has checked and verified the final track condition.

B. Refer to deliverables specified herein for reports required in connection with completion of tie replacement work.

END OF SECTION
SECTION 20400
TRACK CONSTRUCTION

PART 1 – GENERAL

1.01 DESCRIPTION

A. Section includes specifications for track construction, including surfacing existing track and turnout and shifting and raising or lowering existing track.

1.02 REFERENCE STANDARDS

A. American Railway Engineering and Maintenance of Way Association (AREMA):
   2. Portfolio of Trackwork Plans (Portfolio)

B. Federal Railroad Administration (FRA):
   1. 49 CFR Part 213, Track Safety Standards

C. Applicable General Orders of the California Public Utility Commission (CPUC)

1.03 SYSTEM DESCRIPTION

A. Trackwork shall be constructed in accordance with the Contract Documents and AREMA Manual and Portfolio.

1.04 SUBMITTALS

A. Submit plan for handling of materials and construction of tracks for Engineer’s approval. Plan shall include proposed equipment used to line, surface, tamp, and compact the track structure; and regulate and sweep ballast.

B. Methods and equipment proposed for achieving required thermal stress in the CWR to the Engineer prior to fastening rail to crossties.

C. Plan for providing a signal support crew to protect and maintain the operating signal system. Refer to Section 01005, Contractor’s Personnel and Equipment, for related submittals.

D. If the Contractor proposes alternate construction staging plans, submit plans for the prior approval of the Engineer.
1.05 DELIVERABLES

A. Submit rail temperature and fastening records on forms furnished by the Engineer for CWR installation.

B. Submit the following prior to starting track construction:
   1. Report confirming subgrade meets Contract requirements.
   2. Survey documenting facilities in the track subgrade and their condition prior to starting track construction.

C. Prior to beginning track construction, submit a report confirming the constructability of the Work based on the construction staging plans as indicated in the Contract Drawings.

D. Submit rail fastening record forms to the Engineer before the end of the shift during which CWR was installed.

E. Submit report confirming that track is ready for tamping, lining, and surfacing.

F. Submit an as-built report with tabulation of the vertical and horizontal positions of the final track alignment to the Engineer for final acceptance of the track.

1.06 QUALITY ASSURANCE

A. Qualifications: Manufacturer of track materials shall have successfully furnished track materials to Class 1 Freight, Passenger or Commuter Railroad. This does not include transit or light rail special trackwork. Track materials shall be new unless otherwise noted on in the Contract Documents to be used or second hand.

B. Regulatory Requirements: Comply with the following:
   1. FRA 49 CFR Part 213 and Part 214
   2. Applicable General Orders (G.Os) of the California Public Utility Commission (CPUC)

1.07 DELIVERY, STORAGE, AND HANDLING

A. Replace damaged crossties, rail, other track material (OTM), and fastener assemblies. If track is constructed with track panels, inspect track panels and rail and store in a designated area within the work site prior to installation.

PART 2 – PRODUCTS

2.01 CONTRACTOR-FURNISHED MATERIALS

A. Furnish all materials, equipment and labor required to complete all aspects of the track construction work as specified and shown in the Contract Documents
except for Owner-furnished materials, equipment and labor. Refer to Sections 01004, Owner Furnished Labor and Equipment, and 01600, Materials.

2.02 OWNER-FURNISHED MATERIALS

A. Refer to Section 01600, Materials for description of Owner Furnished Materials.

B. Salvaged track materials indicated on the Contract Drawings and specified Section 20200, Track Removal and Salvage, shall be considered as Owner-furnished materials if indicated for reuse in track construction.

PART 3 – EXECUTION

3.01 PREPARATION

A. Prior to commencement of trackwork construction, check the track subgrade as to line, grade, and cross section, and compaction. The track subgrade is the bottom of ballast. The track subgrade shall not vary from the design elevations and the line cross sections from the range of plus or minus 1/2 inch.

1. Correct subgrade settlement discovered at this time by repairing the subgrade as specified in Section 02300, Earthwork.

2. Place and compact subballast, if required, in accordance with the requirements of Section 02300, Earthwork.

3. Submit to the Engineer a report confirming that all requirements for the subgrade are met according to the plans and as specified in Section 02300, Earthwork.

3.02 INSPECTION

A. Survey and document the condition of facilities in the track subgrade, including buried conduits, conduit stub-ups, ductbanks, underdrains, and underground utilities. Incorporate the information in a report and submit to the Engineer prior to starting track construction work, operating heavy equipment, and allowing construction vehicles on the track subgrade.

3.03 GENERAL

A. Refer to Section 01011, Work Planning, for plans and procedures regarding work both within and outside the railroad operating environment.

B. Protect facilities in, under, or on the track subgrade during track construction. Repair damages to the facilities which were caused by the Contractor's operations and were not pre-existing as indicated in the Contractor's survey report.

C. Secure screw spikes at right angles to the tie surface, straight down.

3.04 TRACK CONSTRUCTION
A. Track construction shall include main line track construction, non-main line track construction, raise and shift track, and lining and surfacing track.

B. Main line track construction as indicated in the Contract Drawings shall include placing ballast, placing ties, installing continuously welded rail (CWR), installing OTM, de-stressing rail, lining track, surfacing track, regulating ballast, and stabilizing track.

C. Non-main line track construction as indicated in the Contract Drawings shall include placing ballast, placing timber ties, installing second hand CWR or jointed rail, installing OTM, lining track, surfacing track, destressing of rail, and regulating ballast.

D. Raise and shift of main line track as indicated in the Contract Drawings shall include raising and shifting track to the final alignment, placing ballast, replacing damaged or defective ties, fastening loose ties, installing OTM, lining track, surfacing track, regulating ballast, and stabilizing track.

E. Lining and surfacing track as indicated in the Contract Drawings shall include minor track raising and shifting without changing the existing ballast section, placing ballast as required for minor track raising, stabilizing track, and regulating ballast.

F. Lining and surfacing track shall include at least 200 feet of track beyond limits of track construction to ensure smooth alignment transition between new track and existing track.

3.05 SEQUENCE OF THE WORK

A. Schedule track construction work according to the requirements of Section 01040, Track Hours and Track Access.

B. Schedule work in such a manner so that the best use of time under the allowable working time limits is made. Make arrangements to ensure that the materials, equipment and labor needed are planned and in place, including signal support crew.

C. Refer to the construction staging plans, if applicable, in the Contract Drawings for the track construction work and other work that require relocating or reconstructing trackwork.

D. Prior to construction, review the construction staging plans to ensure the constructability of the construction. Refer to submittals and deliverables specified herein for requirement in regard to construction staging plans.

E. Track shall be constructed, brought to final line and grade, and fully ballasted before CWR is thermally adjusted.

3.06 INITIAL LAYER OF BALLAST

A. Place an initial layer of ballast, compact it over prepared subgrade prior to placing track or raising and shifting track.
B. Limit initial layer of ballast to a total compacted depth that will establish the track at an elevation between four (4) inches and six (6) inches below final top of rail elevations as indicated in the track profile of the Contract Drawings.

C. Each lift of initial ballast layer shall not exceed a maximum of four (4) inches in thickness and shall be uniformly spread and compacted with a minimum of four (4) passes with vibratory compactor, unless otherwise approved by the Engineer.

D. Place the initial layer of ballast for ballast deck bridges directly over the waterproofing membrane. Protect the waterproofing membrane and deck drainage pipes.

E. Level the surface of the initial ballast layer and compact uniformly prior to crosstie distribution or track installation.

### 3.07 CROSSTIE DISTRIBUTION

A. Distribute and place ties in their final locations. Install ties perpendicular to the track alignment based on the required tie spacing as indicated in Caltrain Standard Drawings.

B. Position cross ties at joints or welds so that a “suspended joint” arrangement results unless otherwise required by the Engineer.

C. Place ties within plus or minus 1/2 inch of required spacing. Discrepancies shall not be additive.

D. Place ties with the heart wood down and ensure the bottom of each tie fully supported on the initial ballast layer.

E. Replace damaged and defective ties.

F. Before laying rail, clean the wearing surface of the tie and tie plate of any debris.

### 3.08 CUTTING AND DRILLING OF RAIL

A. Use only approved rail saw and abrasive cutting wheel for cutting rail. Cuts shall be square and clean. When given the option of cutting existing rail or cutting the rail being installed, cut the existing rail. Do not use cutting torches on rail; rail cut with torches will be rejected.

B. Drill new holes with a proper template. Do not punch, slot, or burn with torch. Mark and drill each hole location at centers, size, and location shown on the Caltrain Standard Drawings. Peen drilled bolt holes or grind to remove sharp edges. Chamfer holes and rail ends in accordance with Caltrain Standard Drawings. Tolerance for the diameter of drilled bolt holes is plus or minus 1/16 inch.
C. Drill a single handling hole in the ends of CWR, at 9 inches or 15 inches from the end of the rail to suit joint bar hole spacing.

3.09 LAYING AND INSTALLING CONTINUOUSLY WELDED RAIL (CWR)

A. Laying CWR:

1. Lay CWR in-place in a manner that does not damage rail, crossties, tie plates, fasteners, or other appurtenances. Ensure that surface of tie plate or tie pad is free of ballast or other material that would prevent full bearing of the rail on the tie plate.

2. Install prefabricated insulated joint rail plugs at locations as indicated in the Contract Drawings. End post insulation shall be centered in the tie crib closest to the specified location. Cut the CWR string at the insulated joint location and pull it ahead instead of removing a piece from the middle of the CWR string.

3. Determine the rail temperature by means of an AREMA standard rail thermometer as specified in the AREMA Manual. Connect CWR strings with temporary joints that have gaps to provide for thermal adjustment from observed temperature to Desired Neutral Temperature (DNT) of 105 Degrees F.

4. Heat the rail as specified herein to the following required Desired Neutral Temperature Ranges (DNTR): CWR shall be installed within 5 degree of the Desired Neutral Temperature (DNT) of 105 degrees F.

5. If the rail temperature exceeds the maximum specified for that area, the Engineer reserves the right to suspend rail laying operations or require that the rail be cooled.

6. Distribute and position CWR for fastening in a manner to minimize handling over tie plates and to prevent buckling. Use rollers to move strings of CWR. Do not drag CWR along the ground or along crossties.

7. Place rails base down, parallel with track, avoiding excessive bending or damage, using suitable mechanical equipment. Avoid placing rails on manhole covers, electrical connections, or near other installations that could be susceptible to damage or cause damage to the rail.

8. In advance of the rail fastening, determine rail temperature. Place thermometer on web or base of rail shaded from the sun, long enough to record the rail temperature accurately. Check and record rail temperature every 30 minutes during laying.

9. Do not cut rail strings except as required for installation of turnouts, crossovers, and other special trackwork.

10. Position CWR strings so that tie-in welds are staggered by a minimum of 15 feet, unless otherwise approved by the Engineer.
11. Place welds at 25 feet minimum from the edge of grade crossing panels and stagger by a minimum of 15 feet.

12. Pieces of rail longer than 15 feet shall remain the property of the Owner. Pieces of rail shorter than 15 feet shall be removed and disposed.

B. Rail Ends:


2. Any mismatch of rails at joints may not be more than 1/16 inch on the tread and 1/16 inch on gage side.

3. Rail batter is the distance in 1/1000 inch, between the bottom of the straight edge 24 inch long, applied along the centerline of the worn surface of the top of the rail. Limit welding to joints where one rail shows a batter of 1/16 inch or more. Where rail ends are not battered to an extent requiring welding, but where measurement shows a difference in the height of the rails of 1/16 inch or more, build up the low rail to the height of the high rail. Do not make welding repairs past the end of the joint bar or end repairs over a bolt hole.

C. Fastening CWR:

1. Install resilient fasteners, only after the rail has achieved a temperature within the specified range and has been de-stressed to relieve internal stresses.

2. Fasten rail only when its temperature is within 5 degrees F of the opposite rail’s fastening temperature.

3. Prior to de-stressing rail, remove any joint bars or compromise joints installed at the Contractor’s convenience and replace by thermite weld.

4. At the time of joining CWR strings by welding, ensure that the rail has been adjusted to zero thermal stress.

D. Adjustment by Heating:

1. Heat rail with an approved rail heater when installing rail with a rail temperature lower than the specified minimum for that area. Rail lengths of 200 feet or less may be adjusted by a rail puller. For rail lengths over 200 feet, use a rail heater.

2. Adjust rail temperature after it has been laid but before it is fastened or anchored, as applicable. Rail shall not be thermally adjusted before the track is constructed to final line and grade with a full ballast section.
3. At the time of welding, provide a gap at the end of each continuous welded rail equal to the amount of the expansion that is required for that rail plus the required gap for the weld.

4. Begin heating at the end of the rail and steadily apply moving forward without reversing direction until the required temperature range (Desired Neutral Temperature) has been achieved for that rail. Control uniformity of expansion by marking each quarter of the string and introducing expansion as follows:

   1/4 Point   1/4 of total required expansion
   1/2 Point   1/2 of total required expansion
   3/4 Point   3/4 of total required expansion

   a. Mark quarter points with a continuous line from the base of rail to the tie plate or shoulder of concrete tie so that the amount of expansion can be accurately determined. The reference shall be one that will not move as the rail expands.

5. Vibrate the rail along its entire length during heating or after it has achieved zero stress temperature to facilitate the relieving of internal rail stresses (destressing). Use only appropriate vibrators as approved by the Engineer. Do not strike the rail with objects which might damage the rail.

6. The fastening operation shall immediately follow destressing. Fastening of the rail shall occur within the temperature range as specified in this Section.

E. Gaps for Rail Distribution Adjustment:

1. During rail laying below the indicated zero thermal stress or desired temperature, determine the gap between CWR strings by using the following equation:

   \[ G = (t - T)LK + Q \]

   \( G \) = Required rail gap (inches)
   \( t \) = Desired Neutral Temperature (DNT) in degrees F
   \( T \) = Actual rail temperature at time of laying in degrees F (before heating)
   \( L \) = Length of rail in feet (total length of unrestrained rail)
   \( K \) = Coefficient of thermal expansion for rail steel (0.000078 inch per foot per degree F)
   \( Q \) = Rail gap as required by manufacturer of field weld
2. The Desired Neutral Temperature used in the formula above shall be 105 degrees F.

F. Rail Fastening Record:

1. Provide in an acceptable, reproducible, and separate form during installation the following data for each end of a CWR or at each 500 foot interval for rails longer than 1,500 feet:
   a. Date and time
   b. Track number (i.e. MT1) and rail (left or right looking up-station or milepost)
   c. Railroad stationing
   d. Weather, air, and base of rail temperature; the base of rail temperature shall be recorded every 30 minutes.
   e. Type of fastener used
   f. Length of rail being anchored or fastened

3.10 LAYING AND INSTALLING TRACK PANELS OR JOINTED RAIL

A. Installation and placement of track panels or jointed rail:

1. Place track panels on initial layer of ballast according to the final horizontal alignment as indicated in the Contract Drawings.

2. Place each sequential track panel close enough to install joint bars with minimal sliding or handling of track panels.

3. Place tie plates under rails on all crossties. Clean tie plates and center them on the tie so that the rail will have full bearing on the plate and the plate will have full bearing on the tie. Set tie plates at right angles to the rail with the outside shoulder having full bearing against the base of the rail.

4. Lay rail with staggered joints. The joints in each line of rail shall be not more than 30 inches from the center of the opposite rail on tangents and curves up to 6 degrees, or more than 4 feet on curves over 6 degrees. Rails of less than standard length shall be used to space the joints on curves.

5. Adjust rail with squared joints in track panels so rail joints will be staggered as required above.

7. Gap rails at time of laying, before joint bars and bolts are installed, in accordance with the following table for 39-foot rail:

<table>
<thead>
<tr>
<th>Rail Temperature (degrees F)</th>
<th>Expansion (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 6</td>
<td>5/16</td>
</tr>
<tr>
<td>6 to 25</td>
<td>1/4</td>
</tr>
<tr>
<td>26 to 45</td>
<td>3/16</td>
</tr>
<tr>
<td>46 to 65</td>
<td>1/8</td>
</tr>
<tr>
<td>66 to 85</td>
<td>1/16</td>
</tr>
<tr>
<td>Over 85</td>
<td>0</td>
</tr>
</tbody>
</table>

8. Completely bolt joint bars with all bolts torqued. Use expansion shims to provide proper rail gap. Use an AREMA standard rail thermometer to determine the thickness of shims in accordance with the recommendations in “Temperature Expansion for Laying Rails” Chapter 5 Part 5 of the AREMA Manual.

B. Properly apply joint bars with full number and correct size of bolts, nuts and spring washers. Properly tighten joint bolts before spiking rail; tighten the two center bolts in advance of the end bolts. Except insulated joint bars, coat all joint bars on the rail fishing areas with approved track grease prior to assemblage. Similarly, clean all rail ends with a wire brush and apply grease in the areas of joint bar contact.

C. Place bolts with the nuts alternately on the inside and outside of the rail. Place nuts with the flat side toward the rail. Lubricate track bolts. Check rail ends for mismatch. Rail end mismatch exceeding 1/16 inch on the head and 1/16 inch on the gage face of the rail shall be welded and ground prior to placing track in service.

3.11 TRACK TAMPPING, LINING, AND SURFACING

A. Tamp, line, and surface track as follows:

1. Completely construct, gage, spike, or fasten and weld or bolt track in conformance with the requirements specified in this Section prior to tamping, lining and surfacing. Align track with a full ballast section to the final horizontal alignment as indicated in the Contract Drawings.

2. Check the track on the initial ballast layer to ensure all track components including ballast, tie, rail, and OTM meet the requirements specified in this Section and as indicated in the Contract Drawings. Refer to deliverables specified herein for required report confirming that the track is ready for tamping, lining and surfacing.

3. Perform tamping of track including lifting, lining, and surfacing. The tamper shall meet the following requirements:
a. The tamper shall be capable of external control of both line and grade and shall be capable of external control of alignment utilizing a laser guidance system.

b. The tamper shall be an automatic, vibratory, squeeze-type power tamper equipped with fully functional laser liner and 16 tamping heads, capable of raising both rails simultaneously and maintaining cross-level.

c. The tamper shall be a production type tamper-liner capable of lifting, lining, and surfacing track and turnouts within the specified track tolerances and with the specified ballast.

d. The tamper and equipment to be used for tamping operations will be subject to approval by the Engineer.

4. Every tie in the track shall receive two (2) or more full insertions of the tamping heads and shall be tamped from a point 15 inches inside each rail on both sides of the ties to the end of the ties. Tamping will not be permitted in the center of the tie between the above stated limits. Where raising the track has resulted in a void under the center of the tie, lightly fill the center space. Tamp both ends of a tie, inside and outside of the rail, simultaneously.

5. Accomplish track surfacing by a method that will not cause undue bending of rail, straining of joints, and damaged rail fastenings. Raise both rails at one time and as nearly uniform as possible. Limit each track lift to an amount that will not endanger the horizontal, vertical, and longitudinal stability of the track. The maximum lift shall not exceed 4 inches. Raise the track so that a final lift of not less than one inch or more than 2-1/2 inches is necessary to bring the track to proper final grade.

6. Lift all ties that are pulled loose during surfacing operations. Clean plate surface of dirt and ballast, plug, spike, and re-tamp to provide full bearing against the rail.

7. Surface and align track to the tolerances specified in this Section. The number of surfacing passes shall be as necessary to obtain the Engineer’s acceptance of the alignment.

8. The runoff at the end of raise shall not exceed 1/4 inch in 31 feet of track unless otherwise approved by the Engineer.

9. Tamp ties to provide solid bearing against the base of the rail after the track is raised to grade at final surfacing. Just prior to final dressing, stabilize track with a dynamic track stabilizer. Bring up all down ties to the base of rail and machine tamp. The resultant track surface and alignment shall be uniform and smooth.
10. Stabilize all track with a dynamic track stabilizer or work train as specified in the Contract Documents or required by the Engineer. The dynamic track stabilizer shall meet the following requirements:

   a. The Dynamic Track Stabilizer shall be a well proven machine widely used by the railroad industry and capable of applying controlled, accurate stabilizing forces into the track structure at continuous speeds of up to 1mph.

   b. The track may be stabilized with a work train. Refer to Contract Documents for the requirements for using a work train to stabilize the track.

11. During track tamping and stabilizing, add, re-tamp, and re-compact ballast to maintain the depth of ballast indicated on the Contract Drawings.

12. Upon completion of tamping, surfacing and lining operations, the track shall have been fully ballasted, tamped, surfaced, lined, stabilized, and dressed as shown on the Contract Drawings and specified in this Section.

13. Remove excess ballast from the track. After completion, no ballast shall remain on the tops of the ties, tie plates, or fastening systems.

14. Remove and replace overworked and excessively tamped or compacted ballast as determined by the Engineer.

B. Maintain horizontal alignment during the raising operation. Use automated controls on tampers to satisfy this requirement.

C. Apply rail bonding across any bolted joints in accordance with the requirements in Section 18400, Rail Bonding, and obtain approval of the bonding from the Engineer.

D. Perform tests to ensure the operating signal system has been restored. Obtain approval of signal test results from the Engineer prior to opening the track to service.

3.12 TRACK CRITERIA AND TOLERANCES

A. Construct track to the alignment and grade shown on the Contract Drawings. Gage shall be 4 feet 8-1/2 inches. Completed track shall conform to the following tolerances:

   1. Deviation from correct gage timber ties: 1/8 inch

   2. Deviation from correct gage concrete ties: 1/16 inch
3. Track Surface
   a. Runoff in any 31 feet of track at the end of a raise may not be more than: 1/4 inch
   b. Change in cross level or super-elevation over any 31 feet of track may not be more than: 1/8 inch
   c. Deviation from uniform profile on either rail at the mid-ordinate of a 62-foot chord may not be more than: 1/8 inch
   d. Deviation from zero cross-level at point on tangent may not be more than: 1/8 inch
   e. Deviation from design super-elevation may not be more than: 1/8 inch
   f. Difference in cross-level between 2 points less than 62 feet apart on tangents may not be more than: 1/4 inch
   g. Deviation from specified top of rail to top of platform: +0, -1/4 inch
   h. Location of crosstie placement: 1/2 inch

4. Alignment: Maximum deviations for horizontal alignment shall not exceed:
   a. Tangent Track: 1/4 inch at mid offset on a 62-foot chord.
   b. Curved Track: 1/4 inch from correct mid-ordinate on a 62-foot chord.

5. Track shall be constructed to within 1/2 inch of correct horizontal and vertical position as indicated in the Contract Drawings and within the allowable tolerances specified above.

6. Constructed track shall conform to all required minimum tolerances; + (plus) as specified above and – (minus) zero.

3.13 RAISING AND SHIFTING TRACK

A. Perform raising and shifting of existing track and turnouts to permanent new alignments at locations indicated in the Contract Drawings and in accordance with the requirements of these Specifications. Do not shift tracks more than two (2) feet in any single pass.

B. Prior to raising and shifting track or turnout, widen the existing trackbed in conformance with Section 02300, Earthwork, as required to provide a full track subgrade in accordance with the typical section indicated in the Contract Drawings.
C. After track has been raised and shifted, reposition skewed ties and other track components to their proper spacing and alignment. Re-gage track not less than every fifth tie as necessary. When re-gaging track, remove spikes from ties. Destress rails in accordance with these Specifications.

D. Destress rails if track shift is 500 feet or longer on tangent track, or if track shift reduces the curvature of the track.

E. Add to accommodate increase in alignment due to track shift. Adding rail shall be performed as follows:
   1. Remove existing rail anchors
   2. Cut and remove a minimum of 15 feet of existing rail
   3. Install a new section of rail and weld joints
   4. Re-install existing rail anchors
   5. Destress rails in accordance with these specifications

F. Track raise and shift work shall include resurfacing of existing track adjacent to the track shift area as required to maintain the consistent track profile grade.

3.14 REPLACEMENT OF DEFECTIVE RAIL AND DAMAGED RAIL FASTENER ASSEMBLIES

A. Remove and replace rail that has been found to be defective during construction as follows:
   1. In tangent track: with 15 foot minimum length of defect-free rail.
   2. In curved track: with 30 foot minimum length of defect-free rail.

B. Weld defect-free rail into the rail in accordance with Section 20720, Thermite Rail Welding.

C. Replace rail fastener assemblies damaged during tamping, regulating or other track construction operation.

3.15 FIELD QUALITY CONTROL

A. After completion of trackwork construction, check the track alignment as to line, grade, and cross section.
   1. Track alignment and profile with errors exceeding construction tolerances specified in this Section shall be corrected by shifting, raising, or lowering the track.
   2. Submit to the Engineer a report with tabulation of the vertical and horizontal positions of the final track alignment.
3. The track construction is not accepted as complete until the Engineer has checked and verified the final track alignment data submitted by the Contractor.

3.16 TRACK BACK IN SERVICE

A. Refer to Section 01011, Work Planning, for track back in service requirements. Complete the Return to Service Report attached at the end of this Section prior to returning track to service.

B. Perform a visual inspection after installation, but prior to returning track to service to ensure ties and rails are properly fastened, lined, and free of defects that might be caused during installation.

ATTACHMENT FOLLOWS
RETURN TO SERVICE REPORT

Inspection is required to restore track to service following any significant work/outage. All involved parties (Contractor, JPB, Rail Operator) shall inspect and verify conditions. Inspectors shall be trained and qualified under JPB SPTM&C rules as well as the applicable regulations, and shall be familiar with the scope and progress of the work involved.

<table>
<thead>
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<th>Reason for Outage</th>
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<td>Description of Work</td>
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<table>
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<tr>
<th>Date/Time</th>
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<th>Track Number/Name</th>
<th>Weather/Temperature</th>
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<tr>
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<td></td>
<td>Timetable Speed</td>
<td>Current Speed</td>
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| Condition/Remarks |

| Corrective Action Taken |

<table>
<thead>
<tr>
<th>Track is acceptable for return to service</th>
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<tr>
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<table>
<thead>
<tr>
<th>Responsible Party</th>
<th>Contractor Track</th>
<th>JPB Track</th>
<th>Operator Track</th>
<th>Contractor Signal</th>
<th>JPB Signal</th>
<th>Operator Signal</th>
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<table>
<thead>
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<th>Stations</th>
<th>Bridges</th>
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<tbody>
<tr>
<td>Rail</td>
<td>Ties</td>
<td>Fasteners</td>
<td>Excavation</td>
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<tr>
<td>Alignment</td>
<td>Gage</td>
<td>Turnouts</td>
<td>Shoring</td>
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<tr>
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<td>Anchors</td>
<td>Crossings</td>
<td>Footing</td>
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<tr>
<td>Joints</td>
<td>Spikes</td>
<td>Bolts</td>
<td>Falsework</td>
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</tbody>
</table>

END OF ATTACHMENT

END OF SECTION

September 30, 2011

20400-16

TRACK CONSTRUCTION
SECTION 20500
SPECIAL TRACKWORK

PART 1 - GENERAL

1.01 DESCRIPTION
A. Section includes specifications for Contractor-furnished and Owner-furnished special trackwork.

1.02 REFERENCE STANDARDS
A. Caltrain Standard Drawings
B. American Railway Engineering and Maintenance of Way Association (AREMA):
   2. Portfolio of Trackwork Plans (Portfolio)

1.03 DEFINITIONS
A. Special Trackwork: A generic term referring to turnouts, crossovers, track crossings, derails, and similar track items.

1.04 SYSTEM DESCRIPTION
A. Special trackwork shall be configured, fabricated, and installed in accordance with the Contract Documents and AREMA Manual and Portfolio, where applicable.
B. Special trackwork shall be coordinated with signal work. Include coordination of specific signal equipment or components required for special trackwork construction. Refer to Division 18, Signals.

1.05 SUBMITTALS
A. Submit shop drawings prepared using the latest release of AutoCAD at least 30 days before fabrication is scheduled to begin, unless otherwise specified. Submit files in a CD in both Pdf and AutoCAD format. Submit hard copies of shop drawings as specified in Section 01300, Submittals and Deliverables.
B. Submit material data for Contractor-furnished new material.
C. Submit special trackwork packaging method.
D. Qualifications: Submit data documenting each manufacturer’s past performance and projects within the last ten (10) years furnishing special trackwork material to Class 1 Freight, Passenger or Commuter Railroad.
E. Staging Plans: Submit plans include assembly locations, transport methods, and equipment used for prefabricating special trackwork outside of the working track.

1.06 DELIVERABLES

A. Manufacturer of special trackwork (for either Owner-furnished or Contractor-furnished) shall provide to the Engineer the following:

1. 2 copies of conformed design in latest AutoCAD
2. 2 copies of as-builts in latest AutoCAD

B. Installation of special trackwork:

1. Submit Manufacturer's certificates of compliance for special trackwork.
2. Certification of Installation: Submit affidavit by the manufacturer's field representative certifying that the installation of the special trackwork meets Manufacturer and Contract requirements.
3. Submit an as-built report with tabulation of the vertical and horizontal positions of the final track alignment.
4. Submit final shop drawings revised to show any variations from the tolerances, dimensions, lengths, or angles shown on the approved shop drawings.

1.07 QUALITY ASSURANCE

A. Qualifications: Manufacturer of special track shall have successfully furnished special trackwork to Class 1 Freight, Passenger or Commuter Railroad. This does not include transit or light rail special trackwork.

B. All special trackwork, assemble turnouts, crossovers, and derails shall be inspected in the manufacturer’s fabrication shop.

1. Coordinate the details and scheduling of the inspection with the Engineer at least six (6) weeks before the shop assembly inspection. Provide the Engineer with a safe access to the lay down area and assist with the inspection activities as required.
2. Note on the final shop drawings any variations from the tolerances, dimensions, lengths, or angles shown on the approved shop drawings.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Limit the amount of “bundles” for each unit to the absolute minimum possible and indicate in the packaging plan how the materials will be stacked and marked to allow for easy identification of all the components that are part of the same unit.
B. Pack as complete units in secured bundles all turnouts, crossovers, and derails.

C. Mark units, bundles, and boxes clearly with the following information: identification of item contained, Manufacturer’s name, shipping date, unit designation (right or left), number of pieces, destination, and gross weight.

D. Handle special trackwork materials in a manner that will prevent breaking, bending, or other damage during packaging, loading, transporting, and unloading. Do not drop or throw materials from cars, but lift or skid to the ground or other surface. Do not sharply strike special trackwork.

E. Transport and handle insulated joints in a manner that will protect them from damage.

**PART 2 - PRODUCTS**

**2.01 CONTRACTOR-FURNISHED TURNOUTS, CROSSOVERS, AND DERAIRS**

A. Fabricate turnouts, crossovers, and double point split switch derails, including frogs and guardrails, from new materials. Fabricate special trackwork entirely insulated with the proper number of gage plates ahead and behind the extended switchpoints and stockrails and with all other components necessary.

B. Design for turnouts, crossovers, and derails shall conform to Caltrain Standard Drawings. All rail shall be 136 RE rail section.

C. Special trackwork shall be manufactured from head hardened (HH) rail.

D. Spring frogs shall conform to Caltrain Standard Drawings or Engineer approved equal. Castings shall be 3-shot explosion-hardened. Rail shall be deep head hardened rail. Furnish frogs without plates for turnouts and crossovers on concrete ties. Bolts shall be 1-3/8 inch Grade 8 square head with 1/4 inch hardened flat washers and hexagon security locknuts. Lubricate frog bolts and torque to 2,500 foot pounds.

E. Railbound Manganese (RBM) frogs with elastic fastening system shall conform to Caltrain Standard Drawings or Engineer approved equal. Manganese castings shall be 3-shot explosion-hardened in accordance with AREMA Specifications. Heel of the frog shall incorporate a 30-degree cut. Furnish frog plates with one inch round holes except as otherwise indicated on the Caltrain Standard Drawings. Bolts shall be 1-3/8 inch Grade 8 square head with 1/4 inch hardened flat washers and hexagon security locknuts. Lubricate frog bolts and torque to 2,500 foot pounds.

F. Turnouts and crossovers shall be fully insulated and welded from the ends of the stock rails through the switchpoints, insulated joints, closure rails and frog area, including all trim rail and beyond the long switch ties where it shall be welded into the existing track or newly constructed track. This includes the welding of the insulated frog gage plates to the guardrail plates.

G. Switchpoints, stockrails, frogs, and trim rail shall have the two (2) outside bolt holes drilled to facilitate temporary connections during constructing panelized
turnouts and crossovers. Refer to Part 3 of this Section for welding of temporary connections after installation.

H. All switchpoints are extended; the turnout switchpoint shall have a replaceable manganese tip, samson undercut, furnished with rollers and have the two outside bolt holes drilled in accordance with Caltrain Standard Drawings.

J. Switch pack with Hollow Steel Ties (HST) shall be used for new #10, #14, and #20 turnouts on mainline tracks. Switch pack shall include, but not limited to, rails, ties, hollow steel ties, blue rods, and all related components to complete the entire switch pack assembly.

K. All stock rails are extended, samson undercut and have the two (2) outside bolt holes drilled in accordance with Caltrain Standard Drawings.

L. Boltless adjustable guardrails shall have one inch riser furnished with U69 Guard Bar, complete with four (4) shims per guard-rail plate and fastened with Pandrol “E” clips. Determine the length of guardrail and quantity of guardrail plates in accordance with the switch layout. Furnish guardrail plates with one (1) inch round holes and a 1:40 cant.

M. Provide insulated vertical switch rods with AAR bracket for GRS 5F switch machine for the No. 1 and No. 6 positions, where applicable. Furnish all other vertical switch rod locations without AAR brackets.

N. Insulated Joints:
   1. Conform to the requirements in Section 20120, Track Appurtenances and Other Track Material.
   2. Incorporate insulated joints into closure rails in order to eliminate additional welds in turnouts and short pieces of rail.
   3. Furnish insulated joints in lengths of 19 feet 6 inches minimum, and install them with a minimum stagger of 4 feet 8 inches and a maximum stagger of 10 feet 0 inches.
   4. Paint manufacturer’s lift locations or center point on the rail head.
   5. Provide sufficient clearance on insulated joints for the insulated bar rail and Pandrol E2063B clip to properly fit together.
   6. Elastically fastened using Pandrol Fastclip, modified “E” clip, or Engineer approved equal.

O. Ties:
   1. Nominal tie spacing: 19-1/2 inches (wood) and 24 inches (concrete).
   2. Refer to Section 20130, Timber Crossties and Switch Ties, for timber ties for special trackwork.
3. Refer to Section 20140, Concrete Crossties and Rail Fastener Assemblies, for concrete ties for special trackwork

P. Furnish all other track material (OTM) required for construction of turnouts, crossovers, and derails.

Q. Furnish signal bonding equipment as part of the complete special trackwork items.

2.02 SWITCH STANDS

A. Hand throw switch stands shall be Racor 36-EH switch stand or approved equal. Furnish a 14-inch red target with reflective material such as Scotchlite or equal on both sides.

B. Hand throw switch stand for crossovers shall be Racor 36-E switch stand, or Engineer approved equal, furnished with a 40 1/2 inch straight handle providing maximum clearance between tracks. Furnish an 8-inch red target with reflective material such as Scotchlite or equal on both sides.

C. Hand throw switch stand for double point split switch derail shall be Racor 36-EH switch stand, or Engineer approved equal, in accordance with Caltrain Standard Drawings. Furnish a 14-inch round “D” target with yellow reflective material such as Scotchlite or equal on both sides.

D. Derail sign and posts will be Owner-furnished. Refer to Section 01600, Materials, for related requirements.

2.03 POWER SWITCH MACHINES

A. See Division 18, Signals, for type and installation requirements.
2.04 LUBRICANTS

A. Provide the following types of lubricant or Engineer approved equal:

<table>
<thead>
<tr>
<th>Switch Components</th>
<th>Type of Lubricant</th>
<th>Brand/Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Spring Frogs Wing Rail &amp; Base Plates</td>
<td>Graphite</td>
<td>Slip Plate No. 1 – Superior Graphite Co</td>
</tr>
<tr>
<td>2 Switchpoint &amp; Slide Plates</td>
<td>Soy Oil Base</td>
<td>Ultra Green Sprayable – Trac Lubricants &amp; Coatings, LLC</td>
</tr>
<tr>
<td>3 Switch Rods &amp; Hand Throw Switch Stands</td>
<td>Grease</td>
<td></td>
</tr>
<tr>
<td>4 M23 Power Switch Machine</td>
<td>Soy Oil Base</td>
<td>Ultra Green Sprayable – Trac Lubricants &amp; Coatings, LLC</td>
</tr>
<tr>
<td>5 5F Power Switch Machine</td>
<td>Soy Oil Base</td>
<td>Ultra Green Sprayable – Trac Lubricants &amp; Coatings, LLC</td>
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<tr>
<td>6 A-5 Pneumatic Power Switch</td>
<td>Soy Oil Base</td>
<td>Ultra Green Sprayable – Trac Lubricants &amp; Coatings, LLC</td>
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<tr>
<td>7 M23 Power Switch Machine – Gear Box</td>
<td>Petroleum Lubricating, Grease</td>
<td>Lubriplate No. 5555 – Fiske Brothers Refining Co</td>
</tr>
</tbody>
</table>

PART 3 - EXECUTION

3.01 INSPECTION

A. Prior to commencement of special trackwork installation, perform inspection of the following items:

1. Inspect the 8-inch HMAC track underlay and verify its line, grade, cross section, and compaction as specified in Section 02720, Asphalt Paving.

2. In locations where HMAC underlayment is not required, inspect the track subgrade and verify its line, grade, cross section, and compaction as specified in Section 20400, Track Construction.

3. Verify track alignment as to line, grade, and cross section:
   a. Track center distance at crossover locations shall be in conformance with track center distance designed for the crossover. Maximum deviation shall not exceed 1/2 inch of the design distance or alignment.
   b. Track shall be on tangent at locations of the straight side of the special trackwork.

3.02 TURNOUT, CROSSOVER, AND DOUBLE POINT SPLIT SWITCH DERAIL CONSTRUCTION AND INSTALLATION

A. Fully weld turnouts, crossovers and double point split switch derails at joint locations, including both the toe and heel of the frog. Bolt and properly bond
temporary joint locations. Drill only two (2) outside holes on each side at all temporary joint locations. Weld out all temporary joints within 14 days of installation.

B. Dimensions, details and configuration of the turnout, crossover or double point split switch derail shall be as shown on the Caltrain Standard Drawings and the Contract Drawings. Shop drawings of Owner-furnished materials will be provided to the Contractor when they become available.

C. In no case shall a spike or screw spike be within 14 inches of the end of a switch tie.

D. Shift connecting tracks to their new alignments as shown on the Contract Drawings and connect all tracks to the replacement turnout.

E. Tracks shall be within 1/2-inch of the designed alignment prior to placing ballast.

F. Switchpoints/stockrails, rail joints, frogs, and other parts of the turnout, crossover or double point split switch derail shall fit together properly and be of the proper match. Allow two (2) inches of clearance between moving parts of the switch and the top of the ballast.

G. Place ballast as required in the turnout, crossover, or double point split switch derail and raise to proper grade in a minimum of two (2) lifts. The initial lift shall not exceed four (4) inches. The final lift shall not exceed two (2) inches and all tracks shall be brought into final alignment at that time. In addition, stabilize with a dynamic track stabilizer. Surfacing (tamping), ballast dressing requirements, alignment tolerances, and de-stressing shall be in accordance with Section 20400, Track Construction.

1. Use care not to surface through frog utilizing the tampers switch hooks only. Wing rail or frog base plates can be bent or torn and rendered inoperable. Use helper jacks on opposite guard rail and frog itself to lift track and achieve proper surface.

2. Use care when surfacing through switch point section so that rail remains properly seated in slide plates be careful not to allow tamping tools to strike or damage turnout component.

H. After the turnout, crossover, and double point split switch derail and associated track has been completely surfaced, lined, stabilized, and dressed with ballast, place walkway aggregate around the turnout and associated track to the dimensions governed by CPUC General Order 118 and as shown on the Contract Drawings and specified in Section 20110, Ballast and Walkway Aggregate, and Section 20400, Track Construction.

I. Install switch stands and adjust the switch operating mechanisms so that the switch operates smoothly and without requiring excessive forces. Force at end of handle must be verified with a torque wrench designed for testing switch stand resistance. The measured force at end of handle shall not exceed 30 pounds for the lift-up handle position, 50 pounds for the middle handle position, or 75 pounds for the push-down position. Hand throw switch stands shall have
a proper target. Lubricate switch plates and connection points in the switch rod with the lubricants specified herein.

J. Install switch to hold the switch point tightly against the stock rail when stand is in normal position. Adjust switch rods to hold the opposite point tightly against the rail when stand is in reverse position. Secure switch stands with spikes and fasteners to the headblock. Square headblocks with the track prior to tamping.

K. Install and adjust as required all required rods and plates, including switch point rods, switch point rollers, switch stand rods, basket rods, gauge plates, and U5 box and connections.

L. Install signal bonding as required in accordance with Section 18400, Rail Bonding. Coordinate special trackwork installation with signal work.

M. After installation of special trackwork, perform necessary tests to ensure the operating signal system has been restored. Complete all signal testing in accordance with Section 18600, Signal Systems Testing, prior to placing the turnout in service. Obtain approval of signal test results from the Engineer prior to opening the track to service.

N. Refer to Section 01011, Work Planning, for track back in service requirements. Complete the Return to Service Report in Section 20400, Track Construction, prior to restoring track to service.

3.03 PANELIZED TURNOUT, CROSSOVER AND DOUBLE POINT SPLIT SWITCH DERAIL CONSTRUCTION

A. As an option, construct panelized turnout, crossover, and double point split switch derail as a unit or in multiple panels for installation into the track.

B. Provide all equipment, tools and materials necessary to safely move the panelized turnout, crossover or double point split switch derail as a unit or in multiple panels, providing sufficient bearing to avoid excessive stress to the turnout, crossover or double point split switch derail during handling. Repair any damage caused to turnout, crossover, or double point split switch derail during handling and installation to a condition in accordance with this Section and Section 20400, Track Construction.

C. Panelized turnout construction tolerances shall conform to the track criteria and tolerances in Section 20400, Track Construction.

3.04 DERAIL SIGNS

A. Install derail sign and post in conformance with Caltrain Standard Drawings.

3.05 FIELD QUALITY CONTROL

A. After completion of special trackwork installation, perform inspection of the track alignment as to line, grade, and cross section.
1. Correct track alignment and profile with errors exceeding construction tolerances specified in this Section.

2. Prepare an as-built report with tabulation of the vertical and horizontal positions of the final track alignment.

3. Final acceptance will not be granted until work, punch list and as-built data of final alignment are submitted and verified.

END OF SECTION
SECTION 20600
CONCRETE GRADE CROSSINGS

PART 1 – GENERAL

1.01 DESCRIPTION
A. Section includes specification for furnishing and installing concrete grade crossing panels.

1.02 REFERENCE STANDARDS
A. Caltrain Standard Drawings
B. American Railway Engineering and Maintenance of Way Association (AREMA):
C. American Society for Testing and Materials (ASTM International)

1.03 SUBMITTALS
A. Submit crossing panel system shop drawings.
B. Submit list of all crossing panel system materials.
C. Submit installation instructions.
D. Qualifications: Submit documentation for Engineer’s approval that manufacturer has satisfactorily furnished grade crossing panels and complies with qualification requirements specified herein.

1.04 QUALITY ASSURANCE
A. Qualifications of the Crossing Panel Manufacturer: Manufacturer shall have furnished concrete grade crossing panels to Class 1 Freight or Commuter Railroads for use on 10 feet long concrete ties within the past two years.

PART 2 – PRODUCTS

2.01 CONCRETE GRADE CROSSING SYSTEM
A. Grade crossing system shall be designed for 136 RE rail. System shall be complete with all components, including 10 foot long precast concrete crossing panels, rubber seat pads for gage and field panels, assemblies, rubber flangeway inserts, fasteners, metal panel end deflectors and end restraints in accordance with Caltrain Standard Drawings.
B. The panels shall be shunt resistant.
C. Furnish panels with permanent mark on each panel top, imprinted in the concrete during fabrication, indicating the size of rail, weight of panel, manufacturer’s name, and month/day/year of manufacture. Additionally, mark ends of panels with paint indicating size of rail and weight of panel.

D. Materials:

1. Rebar: ASTM Grade 60
2. Steel Angle: ASTM Grade 36

E. Concrete compressive strength shall be minimum 6000 psi.

2.02 CONCRETE CROSSTIES

A. The grade crossing panels shall be compatible with the 10 feet long grade crossing concrete ties. The concrete crossties shall be new 10 feet long flat-top crossties conforming to the requirements in Section 20140, Concrete Crossties and Rail Fastener Assemblies. The concrete crossties and concrete panels shall fit properly together and the ties shall provide a stable load bearing surface.

B. See Caltrain Standard Drawing SD-2212 for rail fastener requirements.

2.03 TIMBER CROSSTIES

A. Timber crossties for concrete grade crossings shall be new 7 by 9 inch by 10 feet 0 inch long. Timber ties shall conform to the requirements in Section 20130, Timber Crossties and Switch Ties.

B. Fasteners for timber ties under the concrete grade crossings: Two 16-inch Pandrol plates, four (4) galvanized Pandrol E-2055 clips, and eight 15/16 inch by 6 1/2 inch long screw spikes.

2.04 OTHER TRACK MATERIALS

A. Except where otherwise required by panel manufacturer, other track materials used in connection with installation of grade crossings shall be as specified in Section 20120, Track Appurtenances and Other Track Material.

B. Ultimate tensile strength of screw spikes shall be 75,000 psi minimum.

C. Rubber inserts or fillers for the grade crossing panels shall be manufactured from 100 percent extruded virgin rubber (virgin SBR – Styrene Butadiene Rubber) and shall meet the following requirements:

1. Rubber filler shall fit both 132# and 136# rail sections. See Caltrain Standard Drawings for dimensions.

2. Rubber filler shall have connector pins at the joints to prevent gaps and maintaining continuity throughout the railroad crossing.

3. Rubber filler shall fit snugly against the top of rail without gaps.
4. Material properties:
   i. Tensile: 2,000 psi
   ii. Elongation: 400%
   iii. Hardness: 65 ± 5 Durometer Shore A

2.05 SOURCE QUALITY CONTROL

A. If the crossing panel manufacturer is different from the tie manufacturer, panel manufacturer shall assemble one complete 10 foot grade crossing panel prototype along with six crossties at the panel manufacturer's plant to demonstrate the compatibility of the two products. Both the panels and the crossties shall fit together properly and provide a stable load bearing surface.

   1. Notify the Engineer sufficiently in advance of prototype assembly to give the Engineer the opportunity to observe the demonstration.

PART 3 – EXECUTION

3.01 DEMOLITION

A. Remove any existing pavement, track structure, ballast, natural ground and other materials down to the elevations shown in the Contract Drawings and as specified in Sections 02100, Demolition, and 02300, Earthwork.

3.02 TRACKBED PREPARATION

A. Excavate existing ballast and other existing base in accordance with Caltrain Standard Drawings and the Contract Drawings.

B. Construct the trackbed, including aggregate base and HMAC underlayment in accordance with Caltrain Standard Drawings and the Contract Drawings.

C. Install surface ditches and other drainage facilities, including track subdrains, as shown on the Contract Drawings. Clean all existing drainage ditches and channels adjacent to the grade crossing and slope to provide drainage away from the grade crossing.

3.03 TRACK CONSTRUCTION

A. Construct track at grade crossings as specified in Section 20400, Track Construction, and related sections, as modified and appended in this Section. No field welds of rail is allowed within the limits of the new grade crossing.

B. Within the limits of the crossing, the gage of the track shall be 56-1/2 inches, plus or minus 1/16 inch.

C. Within the limits of crossing on concrete crossties, place ties at 24-inch spacing. Place transition ties on each end of the crossing as shown on the Caltrain Standard Drawings.
D. Within the limits of crossings on timber crossties, place ties at 20-inch spacing. Place the transition ties on each end of the crossing as shown on the Caltrain Standard Drawings.

E. Outside the limits of the grade crossing and beyond the transition ties, fully box anchor all timber ties for 195 feet on each side of the grade crossing.

F. Final align and surface the track in accordance with the requirements in Section 20400, Track Construction, prior to placement of crossing panels.

3.04 EXAMINATION AND APPROVAL

A. Prior to installation of crossing panels, perform inspection on track final profile, all fastenings of the rail to the ties, and grading.

B. Notify the Engineer prior to installing panels for inspection and approval of the track surface and alignment. Obtain Engineer’s approval prior to installation.

3.05 INSTALLATION OF THE CROSSING

A. Be familiar with the type of installation to be performed, and install the grade crossing system in accordance with panel manufacturer’s installation instructions.

B. Do not to drop or strike the panels.

C. Remove deleterious materials from the top of the ties prior to installation of the concrete panels, and ensure that the panels are seated with good bearing on the ties. Crossing panels shall not “rock” on the crossties once in final position.

D. Install rubber flangeway inserts to fit snugly to the web and (if applicable) head of the rail in accordance with Caltrain Standard Drawings.

E. The crossing components shall fit snugly and have a uniform surface without sharp edges resulting from elevation change between adjacent panels, the panels and the rail, the panels and flangeway inserts, the rail and flangeway inserts, or any other combination of crossing surface components. Crossing surface that has significant elevation breaks greater than 1/4 inch between adjoining components is not acceptable.

F. Weld crossing panels together with a minimum of six 8-inch to 10-inch beads at time of installation, in accordance with Caltrain Standard Drawings. Finished grade crossings shall match grade crossing approach pavement.

G. Install end restraints and metal deflectors on each end of the crossing in accordance with Caltrain Standard Drawings. Tack-weld deflectors and end restraints to the ends of the panels. Fasten end restraints to concrete ties with tack welds. Fasten end restraints to timber ties with screw spikes.

H. Refer to Section 02720, Asphalt Paving. Place asphalt pavement at the ends of crossing panels as indicated on Caltrain Standard Drawings and the Contract Drawings.
I. Fill eye hooks for lifting panels with manufacturer’s recommended epoxy. Final surface shall be smooth and flush with the panels.

J. Provide the necessary signal support. All associated signal tests shall be completed and the results accepted by the Engineer prior to placing the grade crossing in service.

K. Complete paving work at crossing approaches and related drainage, sidewalk, and other work as indicated on the Contract Documents.

3.06 REPAIR OR REPLACEMENT

A. Repair or replace any damage to the concrete panels, flangeway inserts, or other components resulting from handling and installation.

3.07 FIELD QUALITY CONTROL

A. At completion of work, prior to returning grade crossing to service, perform a road test with cars and trucks passing newly installed grade crossing panels at the speed limit to demonstrate the quality of smooth ride on the road and that concrete panels are free of “rocking” action on the crossties.

B. Perform any other tests required by the jurisdictional authority of the roadway.

END OF SECTION
SECTION 20710
FLASH BUTT RAIL WELDING

PART 1 – GENERAL

1.01 DESCRIPTION

A. Section includes specification for welding rails together to Continuous Welded Rail (CWR) strings by the electric flash butt weld process. Rail within turnouts or elsewhere as approved by the Engineer may be thermite field welds in accordance with Section 20720, Thermite Rail Welding.

B. Refer to Sections 20400, Track Construction; 20150, Rail, and 20720, Thermite Rail Welding, for additional requirements.

1.02 REFERENCE STANDARDS

A. American Railway Engineering and Maintenance of Way Association (AREMA):
   1. Manual for Railway Engineering, Volume 1, Chapter 4, Rail

B. American Society for Testing and Materials (ASTM International):
   1. E10 Test Method for Brinell Hardness of Metallic Materials
   2. E94 Guide for Radiographic Examination
   3. E164 Practice for Ultrasonic Contact Examination of Weldments
   4. E709 Guide for Magnetic Particle Examination

C. Federal Railroad Administration (FRA):
   1. CFR 49 Part 213 Track Safety Standards

1.03 SUBMITTALS

A. Submit the following welding equipment and procedures to the Engineer for approval:
   1. Work program and schedules for electric flash butt rail welding.
   2. Working and laying out drawings, manufacturer’s catalog, performance data and detailed specifications of the equipment to be used for rail welding and handling. Include lists and details of equipment or welding plant for the electric flash butt welds.
   3. Welding procedure qualification.
4. Written description of welding ability, including facilities, personnel qualifications and a list of completed projects similar in scope.

5. Procedures for pulling and aligning the rail, allowances for destressing, and procedures for bolt holes.

6. Details of proposed equipment and procedure proposed for straightening welds, if required, including reference data of successful use on previous projects.

7. Proposed facility for storing CWR.

B. Submit detailed description of testing program and procedures to be performed by Inspection and Testing Agency (ITA). Submit a copy of the agreement between the Contractor and ITA at least 30 days before initiating welding operations. Refer to Section 01400, Quality Control and Assurance, for submittal of proposed ITA.

C. Submit the following reports:
   1. Brush recorder charts for each electric-flash butt weld.
   2. Daily summary reports of production rail welding inspection and testing.
   4. Record on each CWR string installed.

1.04 QUALITY ASSURANCE

A. The agreement between Contractor and ITA shall specify the following:
   1. ITA shall submit all original test results directly to the Engineer.
   2. ITA shall promptly provide copies of all correspondence between ITA and the Contractor to the Engineer.
   3. The agreement shall run for the duration of the Contract, except as otherwise agreed to by the Engineer.
   4. Test reports to the Engineer to allow for 7 days review and appropriate action by the Engineer prior to being eligible for payment.

B. Regulatory Requirements: Perform work in accordance with CFR 49 Part 213.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Weld Owner-furnished or Contractor-furnished rail strings into CWR in accordance with this Section.

B. Provide all incidental materials required to complete the work of this Section.
PART 3 – EXECUTION

3.01 RAIL STORAGE AND HANDLING

A. Equipment and methods to handle and store CWR strings shall conform to the requirements of AREMA Manual, Chapter 5, Section 5.2.3, “Handling and Transporting Continuous Welded Rail (CWR).”

B. Do not use any methods that are likely to cause scratching, notching, rubbing, scoring, or striking of the rails.

C. Support CWR strings off the ground and space them such that the load on the supporting ground will not exceed 1,500 pounds per square foot.

D. Store CWR at locations shown on the Contract Drawings or where designated by the Engineer.

3.02 RAIL WELDING

A. Weld rail by the electric-flash butt welding process. Welding shall conform to AREMA Manual, Chapter 4, Section 3.11, Specifications for Fabrication of Continuous Welded Rail, as applicable, except as modified or appended in this Section. All production welding shall use procedures specified in this Section.

B. Each welding machine shall be equipped with a brush recorder to produce charts showing traces of electrical impulses and movable platen travel. Submit chart to the Engineer for each weld. If the chart indicates performance which is not in conformance with the approved standards, the weld will be rejected.

C. Refer to Section 01590, Temporary Facilities. Furnish all mobile electric power and utilities required.

D. CWR Strings:

1. String lengths of CWR shall be in lengths as required to install a single piece of rail meeting the length of the stage of construction or other lengths approved by the Engineer.

2. Paint string number and length with an aluminum paint on both sides of the web of the rail at each end of each string.

3. Weld rails so that Heat Number appears on the same side in each string.

4. Do not weld within 8 inches from a bolt hole.

E. Rail Straightening and Cutting Back:

1. Field align or cut back rail ends not meeting the requirements of AREMA: Chapter 4, Section 3.11, Specifications for Fabrication of CWR.

2. When rail ends cannot be straightened or cut back to achieve the required rail end tolerance, rail will be rejected.
3. Mark rejected rail and stockpile in an on-site area designated by the Engineer.

F. Cutting and Cropping of Rail:

1. Cut clean and square all rails cut prior to welding by means of rail saws or abrasive cutting disks in accordance with AREMA Manual, Chapter 4, Section 2.1, Specifications for Steel Rails. Do not torch cut rail.

2. Crop or cut rails with bolt holes or thermite welds within 2 feet of a weld at least 8 inches behind the bolt hole or thermite weld. If the rail is bent, cut back the rail an additional amount to remove the bend.

3. The small, scrap sections of cropped rail shall become the property of the Contractor and shall be disposed of off-site.

4. After cutting back the rail, slide back the next rail to make ready for the next weld or joint.

5. Close gaps generated during sliding back the next rail by installing a plug of owner-furnished rail.

6. Plugs used to fill the gaps shall be at least 15 feet in length on tangent and 30 feet in length on curved track. Similarly, no rail left in track shall deviate from this requirement.

7. Prior to placing track back into service at the end of each shift, fully spike, bolt, and anchor the rail according to the requirements in FRA Class 4 track.

G. Rail End Preparation:

1. Clean the rails free of grease, oil, dirt, scale and moisture to a minimum of 6 inches back from the rail ends, including the rail end surfaces.

2. Grind rail areas in contact with electrodes to remove mill scale and raised lettering.

3. Align the faces of the rail ends. Divide any difference in the width of the rail heads equally on both sides of the head.

4. Align vertically for a flat running surface. Any difference of height of the rail shall be made in the base.

5. Align horizontally so that any variance in width of the 2 rail heads is split equally between gauge and field side, providing the misalignment along the gauge line does not exceed 0.040 inch. Additional variance shall be apportioned to the field side of the weld.

6. Rail ends shall be square and smooth, and shall show no steel defects, dents or porosity before welding.
H. If more than 300 LF of rail is welded into CWR, destress the length so fabricated and 300 feet of rail in both directions beyond.

I. Conform to the requirements of Section 20400, Track Construction for adjusting and destressing rail in track when rail is pulled.

3.03 WELD QUALITY

A. Each weld shall have full penetration and complete fusion and shall be free of cracks.

B. Small porosity and slag inclusion which show on radiographic film will be accepted if the total area of internal defects does not exceed 0.09 square inch and the largest single defect does not exceed 0.180 inch in diameter.

3.04 WELDING PROCEDURE QUALIFICATIONS

A. Prior to beginning of production welding, make three (3) test welds on each welding machine using the same welding procedure that will be used in production welding. Each test weld shall join two (2) pieces of rail 18 inches in length.

B. Inspection of welding procedures and testing of welds shall be performed by the ITA employed by the Contractor.

C. Test each test weld radiographically with a minimum of 4 exposures: One through the head, one through the web, and one through each of the 2 flanges. Perform radiography in accordance with ASTM E142. Radiographic film shall be Type 1 or Type 2. Exposed film density shall be within the range of 1.5 to 3.8.

D. Magnetic particle test each test weld by the coil method (longitudinal magnetization) using the dry powder method in accordance with ASTM E709.

E. Ultrasonically test each test weld in accordance with ASTM E164. Use equipment capable of detecting a 3/64-inch discontinuity, 6-1/2 inches below top of rail.

F. Test each test weld for hardness in accordance with ASTM E10. Perform this test on the head of the rail in the center of the weld. The hardness of the weld shall be equal to the average Brinell hardness of the two (2) parent rails joined with a permissible variance of 20 Brinell points.

G. Acceptance will be based on the weld quality requirements stated above.

3.05 WELD NUMBERING

A. Mark a sequential weld number on the rail immediately adjacent to the weld using a quality aluminum paint marker at the time the weld is made.

B. Number welds sequentially in the order in which they are made.

C. Obtain the initial weld number from the Engineer.

D. When defective welds are replaced, assign a new sequential number to the new weld by adding a letter to the defective weld number. (e.g. defective weld 109 will be replaced by 109A)
3.06 FINISHING THE WELDS

A. Finish weld with a rail mounted profile grinder specifically designed for the work. Finishing shall conform to the following tolerances:

1. Top of rail head: Plus 0.010 inch to minus 0 inch of the parent rail section.
2. Sides of rail head: Plus or minus 0.010 inch of parent rail section.

B. Finish the balance of the rail section with a hand-held grinder as required to remove notches, protrusions, gouges, visible cracks and other defects. All grinding shall blend to the parent rail section and shall not overheat the steel. Complete heavy grinding while the steel is still hot from welding.

3.07 INSPECTION AND TESTING OF PLANT WELDING

A. The ITA shall perform and report all inspection and testing of production welding as specified herein within 24 hours of making the welds. Keep the Engineer informed regarding testing of production welds so that the Engineer may observe inspection and testing.

B. Visually and dimensionally inspect each weld to determine conformance with the alignment and finishing tolerances in AREMA Manual, Chapter 4, Section 3.11, Specifications for Fabrication of Continuous Welded Rail. Cut out and re-weld out-of-tolerance welds in accordance with this Section.

C. ITA shall magnetic particle test each weld by the coil method (longitudinal magnetization) using the dry powder method in accordance with ASTM E709. Cut out and re-weld welds giving fault indications in accordance with this Section.

D. Ultrasonically test each weld for defects in accordance with ASTM E164. Use testing equipment capable of detecting a 3/64-inch discontinuity, 6-1/2 inches below top of rail. Perform ultrasonic testing after rail has been destressed.

E. Inspect each weld using a 3-foot straightedge along the centerline of the rail and 0.625 inch below top of rail on the gauge side of the rail head. Center the straightedge over the weld; the gap between the straightedge and the rail shall comply with the requirements of AREMA Manual, Chapter 4.

F. Submit to the Engineer a daily summary of results of all testing for each weld on a form containing the following information:

1. Date and shift
2. Inspector's and welding foreman's name
3. Weld number
4. Result of magnetic particle test
5. Result of ultrasonic test
6. Note of any dimensional tolerance or other rejections

7. Certification of acceptance or rejection of weld

G. Submit a summary of CWR strings produced, including the following information:

1. String number
2. Lead Rail heat, ingot and letter
3. End Rail heat, ingot and letter
4. String length
5. String temperature at the time of measurement of length

H. For every rail string installed, record on a form provided in this Section the unique string number assigned to the string, the rail manufacturer of each individual segment of rail that makes up the string, the month and year date that each individual segment of rail was rolled, the length of each individual segment of rail that makes up the string, and the location of each numbered weld that connects each individual segment of rail in the entire string (i.e. Begin String 145, CF&I 04/96 33', Weld 1, PST 10/91 30’, Weld 2 etc….End String 145). The form shall also indicate the stationing where the “Begin String” portion of the string is installed and the stationing of where the “End String” portion of the string is installed, the track number, east/west rail it was installed on (i.e. Being String 145 Sta 1000+10, End String 1010+00, MT-1, east rail).

3.08 REPAIR OF DEFECTIVE WELDS

A. Cut out and re-weld all welds rejected during inspection or testing.

B. Crop rails 6 inches from the center of the defective weld prior to rewelding.

3.09 FIELD QUALITY CONTROL

A. The Engineer may randomly select any welds and request to be retested at any time within the period of the Contract. Replace any defective welds.

B. Prior to completion of welding operation, visually inspect all welds to verify the base riser break off area has been smoothed. Smooth areas which have not been smoothed.

3.10 CLEAN UP

A. Inspect areas where welding operation performed. Collect and dispose any remaining scrap sections of cropped rail daily after completion of welding operation.

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END OF SECTION
SECTION 20720
THERMITE RAIL WELDING

PART 1 - GENERAL

1.01 DESCRIPTION

A. Section includes specifications for welding rails together by the Thermite process at the project site for the purpose of joining rail strings and for other in-track welds.

B. Refer to Section 20400, Track Construction; Section 20150, Rail, and Section 20710, Flash Butt Rail Welding, for additional requirements for thermite welds.

1.02 REFERENCE STANDARDS

A. American Railway Engineering and Maintenance of Way Association (AREMA):
   1. Manual for Railway Engineering (Manual), Volume 1, Chapter 4, Rail

B. American Society for Testing and Materials (ASTM International):
   1. E164 Standard Practice for Ultrasonic Contact Examination of Weldments
   2. E709 Standard Guide for Magnetic Particle Examination

C. Federal Railroad Administration (FRA):
   1. CFR 49 Part 213 - Track Safety Standards

1.03 SUBMITTALS

A. Submit detailed procedure specification of the step-by-step methods to be employed in making the welds for Engineer’s approval. Include complete description of each of the following items, as applicable:

1. Manufacturer’s trade name for the welding process.

2. Method used for cutting and cleaning the rail ends. Refer to Section 20400, Track Construction, for allowable means of cutting rail.

3. Minimum and maximum allowable gap between rail ends prior to welding.

4. Methods used for cleaning multiple-use crucibles and removing moisture, and the procedures for tracking the number of welds made. If single-use crucibles are used, the above mentioned procedure will not be required.

5. Method used for preheating, including time and temperature.
6. Method used for removing the upset metal and finishing the weld to the final contour, including a description of special tools and equipment.

7. Quality control procedures to be followed.

B. Submit welder qualifications and certification from weld-kit manufacturer for Engineer’s approval.

1.04 DELIVERABLES

A. Prepare welding testing record in a form acceptable to the Engineer. Submit signed original form to the Engineer within 14 days of completion of the weld testing.

B. Submit a weld record for each weld indicating weld number, location, rail temperature, date and time of weld, and name of welder within 72 hours of completing the weld.

1.05 QUALITY ASSURANCE

A. Perform welding under the direct supervision of an experienced welding supervisor or foreman. Welding supervisors and foremen shall be familiar with FRA parts 213.119, 213.305, 213.341 and 213.343.

B. Welders shall be certified by weld kit manufacturer

C. Verify that weld kits have not expired.

D. Test weld prior to allowing revenue train traffic over.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Handle weld kits with care from receipt to installation to ensure high quality welds.

B. Identify weld kits by brand name in the original Manufacturer’s container. Store weld kits in a moisture-proof container.

C. Use weld kits prior to the expiration date. Remove expired weld kits from Owner’s property.

PART 2 - PRODUCTS

2.01 RAIL WELDING KITS

A. The following rail welding kits are approved.

1. Calorite, limited or standard preheat, by Calorite Inc.

2. Boutet, distributed by Esco.
3. Orgo-Thermit, by Orgo-Thermit, Inc.

PART 3 - EXECUTION

3.01 GENERAL

A. Perform welding in accordance with the requirements of the AREMA Manual, Chapter 4, Section 3.13, Specification for the Quality Assurance of Thermite Welding of Rail and Section 3.11, Specifications for Fabrication of Continuous Welded Rail, except as modified or amended by this Section.

B. Weld second hand rail according to the requirements of the AREMA Manual, Chapter 4, Section 3.12, Inspection and Classification of Secondhand Rail for Welding, for Class 1 Rail.

C. Position weld in the crib between two ties. Do not place weld on a tie. Field welds are not permitted in road crossings.

D. Weld compromise joints using in track thermite welds for compromise joints.

E. Do not weld in rain, or other inclement weather without adequate protection from the elements.

3.02 END PREPARATION

A. Clean the rails to be welded of grease, oil, dirt, loose scale, and moisture to a minimum of 6 inches back from the rail ends, including the railhead surface. Use a wire brush to completely remove dirt and loose oxide, and use oxygen-acetylene torch to remove grease, oil and moisture.

B. Align the rail ends using a rail beam specifically designed for this purpose or a 36-inch straight edge.

C. Use a power grinder with an abrasive wheel to remove scale, rust, burrs, lipped metal and mill brands which would interfere with the fit of the mold for two (2) inches on each side of the ends. Rail ends shall show no steel defects, dents, or porosity before welding.

D. Cut rail square using approved rail saws.

E. Field welds shall be no closer than 8 inches from any existing bolt hole.

3.03 GAP

A. The minimum and maximum spacing between rail ends shall be as specified by the rail welding kit manufacturer and the approved procedure specification. Wide gap welds will not be permitted unless approved by the Engineer.
3.04 ALIGNMENT

A. Properly gap and align the ends of the rails to be welded to produce a weld which shall conform to the alignment tolerances below. Hold the rail gap and alignment without change during the complete welding cycle.

1. Alignment of rail shall be done on the head, web, and base of the rail.

2. Vertical alignment shall provide for a flat running surface. Any difference of height of the rails shall be in the base.

3. Horizontal alignment shall be done in such a manner that any difference in the width of heads of rails shall occur on the field side.

4. Maximum horizontal offsets: 1/25 inches in the head and/or 1/8 inches in the base.

5. Surface Misalignment Tolerances:
   a. Maximum combined vertical offset and crown camber: 1/25 inches per foot at 600 degrees F.
   b. Maximum combined vertical offset and dip camber: 1/10 inches per foot at 600 degrees F.

6. Gage Misalignment Tolerance: Maximum combined horizontal offset and horizontal kink camber is 1/25 inches per foot at 600 degrees F.

3.05 THERMITE WELD PREHEATING

A. Preheat the rail ends prior to welding to the temperature and for the time specified in the approved welding procedure specification to ensure full fusion of the weld metal to the rail ends without cracking of the rail or weld. Engineer will reject welds that were made without the rail first properly preheated in accordance with the manufacturer’s recommendations.

3.06 THERMITE WELD COOLING

A. Leave the molds in place, after tapping for a sufficient time to permit complete solidification of the molten metal, in order to allow proper slow cooling in order to prevent cracking and to provide a complete weld with proper hardness and ductility.

3.07 WELD FINISHING AND TOLERANCES

A. Bring welded joints in the finished track to a true surface and align by means of an approved grinding or planning machine (shear). Use a hand grinder for the final smoothing and for areas not accessible to a track grinder. Perform finish grinding with an approved grinder operated by a skilled workman. Take care to grind evenly and leave the joints in a satisfactory condition. Finishing shall eliminate all cracks. Complete the completed weld by mechanically controlled grinding in conformance with the following requirements:
1. Tolerances: A finishing deviation of not more than plus or minus 1/100 inches of parent section of the rail will be allowed.

2. Welds produced by welding kits which are specially designed to produce reinforced welds need not be ground in the fishing area except as necessary to remove fins, burrs, cracks, etc.

3.08 WELD QUALITY

A. Each completed weld shall have full penetration and complete fusion and be entirely free of cracks or fissures.

3.09 WELD NUMBERING

A. Semi-permanently mark a sequential weld number, rail temperature, and date on the rail immediately adjacent to the weld using a quality paint marker at the time the weld is made.

B. Number the welds sequentially in the order in which they are made.

C. Obtain the initial weld number from the Engineer.

D. When defective welds are replaced, assign a new sequential number by adding a letter to the defective weld number (e.g. defective weld 109 would be replaced by 109A).

3.10 FIELD QUALITY CONTROL AND TESTING

A. Visually inspect all welds at the time of welding and during the grinding operation.

B. Prior to completion of welding operation, visually inspect all welds to verify the base riser break off area has been smoothed.

C. Visually inspect and check welds in accordance with approved procedures to ensure there are no surface defects such as cracks and to verify that the welds conform to the alignment and finishing tolerances specified in this Section.

D. Each completed field weld shall be marked with the date, name of welder, air temperature, and rail temperature or with date, name, and “free weld” for welds not used to control CWR thermal adjustment.

E. Verify that each completed weld has full penetration and complete fusion and is entirely free of cracks or fissures.

F. Perform the following tests on all welds. All testing shall be performed by a qualified Independent Testing Agency (ITA) hired by the Contractor. Refer to Section 01400, Quality Control and Assurance. The testing agency shall provide test results directly to the Engineer.

1. Ultrasonic testing shall be performed after the weld has been ground and finished to specified tolerances. Ultrasonic testing shall be
performed in accordance with ASTM E164. Equipment used shall be capable of detecting a 3/64-inch discontinuity, 6-1/2 inches below the top of rail.

G. The weld quality, finishing and alignment requirements specified in this Section shall also apply as requirements of acceptance.

H. Perform testing of welds in active tracks within 96 hours after placing the track back in service. Perform testing of welds in other tracks prior to placing the track in service. Replace unacceptable welds in accordance the requirements of this Section.

I. The Engineer may randomly select any welds to be retested at any time within the period of the Contract. Such testing shall be performed by Contractor-hired ITA.

3.11 REPLACEMENT OF DEFECTIVE WELDS

A. Welds made outside of the track which the Engineer determines to be unacceptable prior to rail installation shall be cut out, rails pulled together to the indicated rail gap, and re-welded.

B. Cut unacceptable welds and replace with a section of rail and 2 new welds. The minimum length of the new rail used shall be 15 feet.

C. Saw cuts shall be made at least 6 inches from the centerline of the faulty weld. In-track welds shall be made in accordance with the requirements specified in this Section.

D. Ultrasonically test the replacement welds as specified in this Section.

E. Install joint bars on defective welds in active track immediately upon completion of testing, and under no circumstances later than 8 hours after testing in accordance with Section 20120, Track Appurtenances and Other Track Material, and comply with FRA Standards Part 213.

3.12 CLEAN UP

A. Inspect areas where welding operation performed. Collect and dispose any remaining scrap sections of cropped rail daily after completion of welding operation.

ATTACHMENT Follows
## ATTACHMENT 20720
### RECORD OF FIELD WELD

<table>
<thead>
<tr>
<th>INSTALLATION</th>
<th>WELDER’S NAME</th>
<th>WELD NUMBER</th>
<th>RAILROAD</th>
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<tbody>
<tr>
<td>FINAL INSTALLED LOCATION</td>
<td>TRACK</td>
<td>RAIL WEIGHT</td>
<td>STATIONING</td>
</tr>
<tr>
<td>DATE</td>
<td>TIME</td>
<td>AM PM</td>
<td>COMPLETE WELD (YES/NO)</td>
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<tr>
<td>AIR TEMPERATURE</td>
<td>°F.</td>
<td>WEATHER</td>
<td></td>
</tr>
<tr>
<td>RAIL TEMPERATURE</td>
<td>°F.</td>
<td>PRE-HEAT TIME</td>
<td></td>
</tr>
<tr>
<td>WELD KIT MANUFACTURER</td>
<td>WELD INGOT #</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RAIL GAP (NEAREST 1/16 INCH)</td>
<td>RAIL CUT REQUIRED? (Circle)</td>
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<td></td>
</tr>
<tr>
<td>BACK RAIL</td>
<td></td>
<td></td>
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<tr>
<td>MANUFACTURER</td>
<td>RELAY RAIL? (Circle)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>YEAR/MONTH ROLLED</td>
<td>HEAT NUMBER</td>
<td></td>
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<tr>
<td>AHEAD RAIL</td>
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<tr>
<td>MANUFACTURER</td>
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<tr>
<td>YEAR/MONTH ROLLED</td>
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<tr>
<td>REMARKS</td>
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</table>

ULTRASONIC TEST DATE AND RESULTS

KIT MFG. REPRESENTATIVE PRESENT | WELDING FOREMAN (Signed) |
PCJPB’S REPRESENTATIVE PRESENT | RECORDER (Signed) |

END OF ATTACHMENT

END OF SECTION

20720-7

THERMITE RAIL WELDING