



ELECTRIFICATION STANDARD SPECIFICATIONS



JANUARY 1, 2026
EDITION



**CALTRAIN ELECTRIFICATION
STANDARD SPECIFICATIONS
JANUARY 1, 2026**

These Caltrain Standard Specifications supersede the “Overhead Contact System Specifications” dated January 1, 2024 and provide coverage of additional electrification elements such as traction power and SCADA. They are therefore denoted as the First Edition of the Caltrain Electrification Standard Specifications.

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

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SECTION 33 75 48

HIGH-VOLTAGE OUTDOOR BUS AND SUPPORTING STRUCTURES

PART 1 – GENERAL

1.01 DESCRIPTION

- A. This Section covers the requirements for furnishing and installation of outdoor bus and supporting structures for high voltage equipment.
- B. Provide bus and supporting structures as specified and described on the Contract Drawings as the basis for the design, or an approved equal.

1.02 RELATED SECTIONS

- A. Related requirements are included in, but not limited to, the following Sections:
 - 1. 34 31 03 - General Traction Power Requirements
 - 2. 34 31 51 – Substation and Gantry Post Insulators

1.03 REFERENCE STANDARDS

- A. Codes and standards referenced in this section shall be those in effect at the time of Contract award. Furnish products that comply with the latest applicable provisions of the following standards and model codes:
 - 1. American National Standards Institute (ANSI)
 - 2. American Society of Mechanical Engineers (ASME)
 - 3. Institute of Electrical and Electronics Engineers (IEEE)
 - 4. National Electrical Manufacturers Association (NEMA)
 - 5. National Fire Protection Association (NFPA)

1.04 SUBMITTALS

- A. Drawings
 - 1. Plan, elevations views of high voltage bus, equipment and bus supporting structures.
 - 2. Erection drawings shall show the relationship of all structural elements and the attached electrical equipment. The size and length of bolts in each connection shall be clearly indicated. The bill of material shall show the piece number and sheet number of the corresponding detail drawing. The total number of each diameter and bolt length shall be tabulated.

3. Assembly breakdown with reference to detailed parts list.
- B. Test Procedures, and Test Result reports
 1. Submit field test procedures and test reports to demonstrate that the equipment will be tested to verify that it performs all functions in accordance with the contract documents, industry standards and with the approved product drawings.
- C. Detailed Parts List

1.05 QUALITY REQUIREMENTS

- A. Provide products for a manufacturer specializing in high voltage bus and bus fittings for a minimum of ten (10) years.
- B. Utilize a documented quality assurance and quality control program in all aspects of the production process.
- C. Furnish only products that will comply with IEEE standard C2 (National Electrical Safety Code), for switching of capacitive loads characteristic of high voltage transmission lines.
- D. Provide assemblies that have passed documented design performance tests.

PART 2 – PRODUCTS

2.01 PROJECT CONDITIONS

- A. Refer to Specification Section 34 31 03 General Traction Power Requirements.

2.02 GENERAL REQUIREMENTS

- A. Furnish outdoor bus and supporting structures with the following characteristics and ratings:
 1. Suitable for application on a 115kV, 3 phase, 60 Hz service.
 2. Rated maximum operating voltage of no less than 121 kV RMS.
 3. Maximum continuous operating current of no less than 600 A RMS.
 4. Momentary short-circuit withstand performance greater than or equal to 40 kA RMS.
 5. Full wave withstand voltage peak of no less than 550 kV.
 6. Bus supports shall consist of a supporting structure, insulator and all hardware fittings and connectors.
 7. The manufacturer shall fabricate the structures in accordance with PG&E standards.

- B. Furnish bus conductors, fittings and connectors as follows:
1. For vibration damping, the manufacturer shall install, at the factory, an inner aluminum tube lining inside the aluminum bus for all spans exceeding 20 feet in length. The inner tubing shall be free to rotate. The bus liner shall be made of 6063-T6 aluminum alloy or equivalent.
 2. All bus conductor ends, not terminated in a fitting or connector shall be provided with end plugs consisting of drive-fit corona bells.
 3. Bus conductors shall be 3 inch, schedule 40 SPS 6063-T6 aluminum alloy unless otherwise indicated.
 4. In order to avoid cantilever stresses on insulators due to the thermal expansion or contraction, sliding bus supports and flexible wire jumpers to equipment shall be provided, where necessary and as indicated. These connectors must be specifically approved for the purpose.
 5. All bus connectors shall be aluminum and shall be designed for making bolted connections in the field. The manufacturer shall submit detail drawings of the connectors, where connections to the transformer bushings, circuit breakers, surge arresters, and potential transformer bushings shall be done.
 6. Wherever electrical connections are made between aluminum and copper, care shall be exercised in preventing corrosion due to connection between dissimilar metals.
 7. All hardware, fittings, and connectors shall be designed to minimize radio noise.
 8. All hardware (except bolts, nuts and washers) not integral with the insulators, all connectors (except flexible connectors) and all fittings shall be cast or forged aluminum alloy with mechanical properties not below those of 195-T4 Aluminum alloy. The manufacturer shall fabricate the structures in accordance with PG&E standards.
 - a. Bolts shall be one-half inch minimum.
 - b. Lugs for cable connections shall have NEMA bolt hole spacing. Lugs shall be 2-hole or 4-hole as indicated on the Drawings.
 - c. Connectors shall be manufactured by Homac or equal.
- C. Furnish Bus Support Insulators as follows:
1. Bus support insulators shall be the station type as specified in Specifications Section 34 31 51 Substation and Gantry Post Insulators.
- D. Furnish Supporting Structures as follows:

1. All steel support structures shall be as shown on the drawings and as specified in this Section.
 2. Cable stands for termination of 46 kV cables shall be two or four legged unistrut frames. Cable termination kits shall be rated for 46 kv nominal, 250 kv BIL and shall be suitable for outdoor use. The frames shall be constructed such that the cable supports and cables supported to avoid stress on the cable terminators. All necessary hardware for mounting of the cables and terminators shall be provided.
 3. There shall be sufficient supports for mounting of disconnect switches, operating mechanisms, and related equipment. The supports shall be mounted on the steel support structures and made of 6061-T6 aluminum alloy or stainless steel.
 4. All bolts, nuts and washers used on hardware, fittings and connectors shall be made of stainless steel.
- E. Cable Jumpers
1. Cable jumpers shall be of the size as shown on the Drawings.
 2. AAC jumpers shall be bare aluminum stranded wire conforming to B230 Aluminum 1350-H19 wire for Electrical Purposes and B231 Concentric-Lay-Stranded Aluminum 1350 Conductors. Stranding shall be class AA with 61 strands.
- F. Factory Tests
1. Factory tests shall be performed in accordance with NEMA and/or ANSI Standards. The manufacturer shall make sure that the necessary factory inspection adjustments and assembly are made.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Install bus and support structures as shown on the Contract Drawings and as recommended by the equipment vendor.
- B. Clean bus, bus fittings and terminators prior to installation.
- C. Anti-oxidation compounds shall be utilized for all fittings and terminations in accordance with the manufacturer's recommendations.
- D. All bus fittings and cable terminations shall be torqued in accordance with the manufacturer's recommendations.
- E. Bus installations shall be plumb and true.
- F. Remove burrs and sharp points on all parts to be energized.
- G. All bus and equipment shall be installed to provide at least the clearances

shown on the drawings; but in no case shall be less than the values shown below for high voltage installations.

1. Nominal System Voltage: 115 kV
2. Phase-to-phase clearance: 15' – 0" except at transformer and circuit breaker bushings.
3. Phase-to-ground clearance: 16' – 0" except at transformer and circuit breaker bushings.
4. Phase conductor-to-metal structure clearance: 7' – 0" except at insulators.

3.02 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 1. Perform inspections in order to assure proper mechanical operation of switches and interlocks, and also the proper fit and assembly of the component parts of the station.
 2. Verify that the installation satisfies the specified electrical clearances.
 3. Verify that burrs and sharp points on parts to be energized have been removed.
 4. Verify that fittings have been torqued.
 5. Verify that the installation does not cause stress to be applied to bushings and terminators.
 6. Perform insulation resistance tests utilizing a 2500 VDC megger.
 7. Complete startup checks according to manufacturer's written instructions.
 8. Perform each visual and mechanical inspection and electrical test stated in an approved energization test plan.
- B. Perform installation, acceptance, and commission tests in accordance with approved field test procedures.

END OF SECTION

SECTION 34 30 03

OCS GENERAL AND INTERFACE REQUIREMENTS

PART 1 - OVERVIEW

1.01 PURPOSE

This document outlines the general requirements associated with the design, supply, procurement of materials, manufacture, fabrication, supply, quality control, installation, inspection, testing services, verification, certification and training necessary to complete Caltrain's 2X25kV,60 Hz AC Overhead Contact System work. These specifications shall be read in accordance with all relevant specifications for materials, Caltrain's standard drawings, design criteria and contract documents.

Materials produced to this specification will be installed as part of Caltrain's Overhead Contact System. In service, they may be simultaneously subjected to the influence of full rated static load, exposure to relevant weather conditions and atmospheric pollution, and shock loads due to installation or maintenance work or wiring damage. Equipment shall be designed to operate satisfactorily under worst-case non-operating conditions without permanent deformation and the incorporation all environmental factors per Caltrain's Design Criteria.

1.02 SCOPE

The overview and general requirements section (34 30 03) details:

- A. The structure of procurement documentation and quality assurance activities that shall be completed to facilitate handover of traction power infrastructure into operation.
- B. Common minimum requirements across all OCS technical specifications.
- C. Common terminology.
- D. The risk exposures covered by this specification include:
- E. Inadequate selection, design and quality assurance of OCS equipment leading to infrastructure which is not fit for purpose or presents unacceptable safety hazards.
- F. Inadequate verification and validation processes to confirm the performance and safety of alterations or additions to the electrification scheme leading to inefficient handover of project works into operation.
- G. Failure of overhead line components in service could result directly or indirectly in serious injury to the public, workers, damage to infrastructure and may affect reliability of service.

PART 2 - REQUIREMENTS

2.01 GENERAL REQUIREMENTS

As part of this project, an Overhead Contact System will be furnished and installed within the project limits provided in the Contract Documents. The work associated with the Overhead Contact System is shown on the Contract Documents and is generally as follows:

- A. Provide a complete OCS for electrification within the Project Limits, including all equipment necessary to form the electrical circuit between traction power substation positive feeders at pole-top disconnect switches and the contact wire interface with the light rail vehicle pantograph.
- B. Provide a complete OCS for crossovers at interlockings as shown on the plans.
- C. Provide OCS sectionalizing equipment at interlockings as shown on the plans and phase break equipment at new traction power facility locations (as required).
- D. Provide and connect OCS feeder, auto-transformer feeder (ATF) and return cables to link the OCS/track system to new traction power substations, new traction power switching station and new paralleling (balancing) stations.
- E. Provide OCS Operation and Maintenance manuals, As-Built Drawings, Special Tools, Spare Parts and Training for Caltrain personnel.
- F. All OCS work shall be fully installed, adjusted, tested and commissioned in place in accordance with applicable portions of these Specifications and as shown on the Contract Documents, including demolition and reconstruction of existing OCS where required for integration.
- G. The Contractor is responsible to take corrective actions and repair any construction errors, at no additional cost to Caltrain. The Contractor shall also provide ongoing construction design support, including preparation of hanger calculations, cantilever cutting dimensions, and all components needed to complete OCS construction.
- H. The Civil Contractor shall be responsible for work required to install OCS foundations and for providing as-built records of those foundations. The Systems Contractor shall be responsible for all other OCS work, including field testing of grounding systems.
- I. OCS scheduling and construction shall be coordinated jointly by the Civil Contractor and Systems Contractor with other project work, including civil work, trackwork, and signaling. At interfaces with existing revenue lines, the Systems Contractor shall plan and perform reconstruction work to minimize impact on daily revenue service, potentially during service shutdowns, nights, or weekends.

2.02 SELECTION OF OCS EQUIPMENT

- A. All new materials and designs to be installed as part of Caltrain's Overhead Contact system shall have prior (type) approval from Engineering, PCJPB or their delegated representative.
- B. Materials to be installed are selected from Caltrain's System design range of components and assemblies.

- C. Materials shall conform to this specification, to the OCS specifications and to all relevant authorized Caltrain Standard Drawings and documents issued for project work.
- D. Materials and components manufactured to applicable foreign standards, including metric standards, are acceptable if the Contractor provides written evidence in English that they meet or exceed the standards listed above, with written approval from the Engineer. Weights and dimensions shall be provided in both Metric and English units, where applicable.
- E. All steelwork and steel components and other ferrous components (except stainless steel) shall be hot-dipped galvanized, unless otherwise noted.
- F. The requirements for inspections, tests, identification and control of records shall be complied with to ensure safe and efficient handover of projects into operation.
- G. The Contractor shall prepare a Contractor's OCS design package with all detailed information required for the OCS installation, including shop drawings for all assembly references, components and materials; designs for construction staging; safety screens for bridges; proposals for signage type, fixing and location; and an OCS Installation Manual.
- H. The Systems Contractor shall be totally responsible for the engineering, form, fit and function of all components supplied. Suppliers shall have a minimum of 5 years' experience in OCS hardware manufacture. Detailed shop drawings shall identify physical size, strength, form and fit for each assembly reference.
- I. All OCS hardware shall be supplied to meet construction requirements and achieve the project schedule. OCS support and wiring assemblies shall primarily be furnished by one experienced supplier (e.g., ABB, Delta Star, Siemens, or equivalent, subject to approval). At interfaces with existing OCS, new components shall be compatible with existing materials.
- J. For construction staging, the Systems Contractor shall submit coordinated OCS staging plans, including temporary arrangements, for approval. The Contractor shall supply all necessary temporary materials to maintain safe, reliable revenue operations.
- K. Prior to field testing, the Systems Contractor shall prepare an OCS test plan and procedures for approval. All tests shall ensure configurations perform to specifications, including electrical tests. The Contractor shall provide field support for commissioning and integrated system testing, including up to 200 man-hours of maintenance assistance post-revenue service.
- L. For recovery of redundant OCS materials, the Systems Contractor shall remove unused assemblies as shown and return them to Caltrain in serviceable condition.
- M. As-Built documentation, including OCS Structure Record Drawings for each location, is required as a project submittal.

- N. Warranty: All OCS goods, supplies, systems and equipment (except spares) shall be unconditionally guaranteed for a minimum of 1 year after Final Approval. Spare parts warranty shall extend for 1 year from placement into service or until 1 year after Final Approval, whichever occurs first.

2.03 OCS

Materials supplied for OCS shall comply with the relevant industry standards, Caltrain's Design Criteria, Master Specifications and Standard Drawings.

The OCS Contract Drawing set comprises site-specific plans (e.g., sectionalizing diagrams, master overlap charts, OCS wiring layouts) and contract standard plans (e.g., general drawings, technical sheets, general arrangement drawings, typical structure drawings, typical span drawings, assembly drawings). The Contractor shall adhere to standards in these drawings for design completion.

2.04 RELIABILITY AND SAFETY

Items shall be selected endeavoring to eliminate risk of injury to persons involved in manufacture, fabrication, installation and disposal complying with relevant legislative requirements.

2.05 SOURCING OF MATERIALS AND EQUIPMENT

All materials used for new projects and infrastructure renewals shall be new, unless expressly approved by the Director of Engineering, Caltrain, based on a sound risk assessment endorsed by the Manager Traction Power/OCS Caltrain. Approval shall be documented as an official derogation.

All materials used shall be of high quality, reliable, and with minimal maintenance requirements.

All materials shall be procured from sources that demonstrate the ability to supply quality products and meet all Buy America requirements.

2.06 DOCUMENTS SUPPORTING RELIABILITY CLAIMS

Where required on the applicable Caltrain's detailed specification for materials, or by Director of Engineering, Caltrain, tenderers shall submit statements or evidence in support of the reliability and performance claimed for the items offered. Statements and evidence such as information and results of Failure Mode and Effect Analysis or similar risk assessment procedures carried out on the offered item shall be submitted.

Documents with the following statements pertaining to the items offered are required and shall be submitted:

- 1) The period of service achieved by the items offered within California or similar service conditions.
- 2) Railroads in the United States who have a service history of the items offered, including contact details of relevant persons from the rail authorities who can provide verification of the claimed service and reliability performance.

- 3) Overseas railway agencies who have a service history of the items offered, including contact details of relevant persons from the rail authorities who can provide verification of the claimed service and reliability performance.

2.07 SAFETY INSTRUCTIONS AND TRAINING

Safety instructions and training material in the form of drawings, instructions and/or audio visuals may be required for the items accepted under the offer.

Tenderers shall state the availability of training materials which should include (but is not limited to) the following topics:

- 1) Handling
- 2) Storage
- 3) Application (particularly in areas of heavy coastal pollution)
- 4) Installation
- 5) Maintenance
- 6) Environmental performance
- 7) Electrical performance
- 8) Mechanical performance
- 9) Disposal

For details see part 23 (Section 34 30 93) of the specifications.

2.08 REFERENCES

- A. CPUC GO-95, Rules for Overhead Electric Line Construction.
- B. CPUC Resolution SED-2, Adopting Safety Requirements Governing the Design, Construction, Installation, Operation, and Maintenance of the 25 kV AC (Alternating Current) Railroad Electrification System of the Peninsula Corridor Joint Powers Board (Caltrain) on The San Francisco Peninsula Rail Corridor.

2.09 SYSTEM CRITERIA

2.10 OVERHEAD CONTACT SYSTEM

- A. The overhead contact system shall conform to the Caltrain Design Criteria and standard system design. System is an auto-tensioned simple catenary, comprising one (1) 70 mm squared 19 strands bronze BZ-II messenger wire and one (1) 107 mm squared CuAg solid grooved copper contact wire.
- B. The Contractor shall be responsible for the complete form, fit and function of all OCS equipment, hardware assemblies and related components supplied.

- C. All drawings shall be prepared by the Contractor for approval by Caltrain.
- D. The Contractor shall also be responsible for any temporary OCS arrangements required to support the staging of the OCS installation work. Temporary components shall include, but not be limited to: poles, foundations, guy anchors, insulators, feeder/jumper cables, static wires, grounding and terminations.

2.11 ENVIRONMENT

The Overhead Contact System equipment, hardware assemblies and components shall be capable of operating satisfactorily in an environment as defined in Section 1.6 of Chapter 1 Design Criteria.

2.12 METALLURGICAL COMPATIBILITY

Components and assemblies having dissimilar metals and have galvanic incompatibility shall not be connected together.

2.13 QUALITY, INSPECTION, TEST AND CERTIFICATION

The Project Manager for the works shall be responsible for the review to minimize risks during the procurement, manufacture and supply of OCS materials.

During the procurement and construction phases, Caltrain shall reserve the right to witness and conduct all the mandatory tests as required in the applicable Caltrain OCS material specifications. These mandatory tests (and other required validation and verification activities) are developed

To ensure that the supplied product or service including those supplied from within the organization meet the safety requirements prior to acceptance and for quarantining and withholding those that have not been cleared for use.

Where appropriate or specified the requirement for traceability of manufacture through batch or other identification is documented.

Validation and verification witness and testing costs shall be borne by the Contractor. The timely compilation of the following certificates is to facilitate safe work on site, avoid rework and achieve an efficient and safe handover process into operation.

Certificate Type	When to Submit
Type Of Certificate	When to be submitted
Type Test Certificates	Prior to equipment type approval
Sample Test Certificates	Prior to equipment acceptance
Test Certificates for Base Materials	Prior to equipment acceptance
Test Certificates for Steel Materials	Prior to equipment acceptance
Test Certificates for High strength Materials	Prior to equipment acceptance
Batch Test Certificates	Prior to Delivery
Certificates of Compliances (product)	At delivery
Installation Complete	At handover

2.14 QUALITY SYSTEM

Components are to be manufactured by companies that have a certified Quality Management System or manufacturers who demonstrate adequate process control systems or accepted quality plans.

The quality assurance requirements need to be agreed between Project Quality Manager at Caltrain and the supplier and shall include a quality / inspection and test plan to ensure product conformity.

The Contractor shall maintain the Quality System at all work sites utilized in the execution of the Contract.

The Contractor shall provide the Project Quality Manager at Caltrain with objective evidence that the manufactured component is in accordance with the contractual requirements.

The Contractor shall ensure that all sub-contractors are capable of supplying equipment and services to a suitable quality level appropriate to the requirements of the Contract.

The Contractor shall ensure that the quality system of the manufacturer is in accordance with the quality system requirements. Documentary evidence of certification to Quality Management System such as ISO 9001 or an equivalent system of both contractor and supplier is required by Caltrain.

2.15 CONTRACTOR'S RESPONSIBILITY

Acceptance of an order by a Contractor, Supplier or Manufacturer is deemed to be an undertaking to provide material which complies in all respects with the relevant drawings, specifications, standards and legislation and to take full liability and responsibility for the items manufactured or offered for use.

The actions of Caltrain inspector do not absolve the Contractor in any way from ensuring that all materials comply with the Specification in every respect. Caltrain inspector or Construction Manager must be present during all final punchlist item resolutions and provide final approval for the completed work.

In the event of the Project Quality Manager at Caltrain agreeing to waive any part of any test or inspection procedure, including witnessing, or to allow any other deviation from the Specification, the Contractor shall remain responsible for the satisfactory quality, performance, dimensions and material of the items concerned.

2.16 SUB-CONTRACTS

Caltrain shall have the right to verify at source, or after receipt, that the works or any parts thereof from sub-contractors conform to Caltrain specification. Where Caltrain elects to verify conformance at a sub-contractor's works, such verification shall not be taken as evidence of control of quality by the Contractor of such sub-contractors. All arrangements for these activities shall be made through the Contractor.

2.17 QUALITY PLAN

Prior to the commencement of manufacture of a component, the Contractor shall incorporate in the Quality Plan submitted with the Tender, any post-tender amendments requested by Caltrain during the tender evaluation.

Within seven (7) calendar days of the Date of Acceptance of Tender, the Quality Plan shall be issued to Project Manager/Lead Engineer-Caltrain.

Project Quality Manager at Caltrain reserves the right to view the work instructions and procedures nominated in the Quality Plan, as being relevant to the contract and as well as verify if these Work Instructions /Procedures are applied to the work.

2.18 INSPECTION AND TEST PLAN

Within seven (7) calendar days of the Date of Acceptance of Tender the Contractor shall prepare an Inspection and Test Plan detailing inspection and test activities associated with the Contract.

All mandatory tests shall be witnessed and certified by the Contractor's Certifying Engineer, where required on the applicable Caltrain's Specification for OCS Materials documents or by Lead Engineer- Caltrain.

2.19 INSPECTIONS AND TESTS

Where tests are not required on every item, samples will be selected as directed by the Inspector. Routine tests are specified either on:

- Caltrain standard drawing or
- in the Detailed Specification or
- applicable standards.

The Contractor shall carry out such tests on all materials, unless otherwise notified in writing by the Lead Engineer-Caltrain.

Apart from the inspections and tests required in the specification and in related documents, the Inspector may take any sample of any item, at any stage of manufacture or after delivery, and subject it to such examinations and tests as he may deem necessary.

Should any defect be found, the entire batch may be rejected by Lead Engineer-Caltrain.

The rejected batch shall be quarantined to prevent its unintended use or delivery. The rejected batch shall be treated for non-conformity, according to the Contractor's quality management system, and shall be subjected to testing deemed necessary by Lead Engineer-Caltrain.

Contractors may rectify rejected components and re-submit them for inspection. The rectified components shall be subject to re-verification and certification by the Contractor's Certifying Engineer, where required on the applicable Caltrain specification for materials documents or by the Lead Engineer-Caltrain, prior to re-submission.

Should any sample fail any further test or inspection, the entire batch shall be rejected and subject for replacement with a new batch. If the contractor fails to complete the rectification or replacement work within the required time or within any extended time

granted in writing by the Lead Engineer-Caltrain, the contractor shall be liable for consequential damages caused by the delay.

The Contract or Order shall not be considered complete until all defects have been rectified or all replacement work has been completed. All costs of the examinations and tests on new batches of materials and for those which are considered to contain defective materials shall be at the Contractor's expense.

2.20 SAMPLES

The manufacturer/supplier shall submit two (2) fully finished samples to Lead Engineer-Caltrain, when requested. Samples are generally used for tests and to assist in the evaluation of offers.

To demonstrate compliance with certain characteristics, trial samples may be submitted which are not fully finished. Such samples shall be clearly marked showing the stage of manufacture represented.

Bulk production must not start until the samples have been inspected and any necessary modifications made as advised by Lead Engineer-Caltrain.

Once the samples are considered acceptable, the Lead Engineer-Caltrain will retain them as "Control Samples" for bulk production. The quality of the components produced under mass production shall be at least equal to that of the accepted "Control Sample".

Approval of samples does not absolve the Contractor in any way from his obligations under other clauses of the relevant Specifications or from ensuring that all items are fit for purpose.

2.21 SAMPLES FOR INSPECTIONS AND TESTS

Where manufacture requires more than one process, the samples for inspection and test may be taken after each and every stage of manufacture at the discretion of the Caltrain Inspector.

Mass produced (industry standard) items may be inspected at a random basis. The Inspector will select samples from each batch offered for visual and dimensional examination.

2.22 DIMENSIONS

Components will be inspected by the Manufacturer and shall comply with their corresponding design drawings and the relevant standard.

The Manufacturer shall provide their own gauges where necessary and make them available to the Inspector when required. The Inspector may, whilst gauging components, reject any falling below the quality of the Control Sample.

It is necessary to ensure that items supplied by different manufacturers will fit together, into the required assembly.

2.23 TEST CERTIFICATES FOR BASE MATERIALS

In addition to specific test certificates required on drawings and/or in the Detailed Specification and/or in the relevant Standards, test certificates will be required for all non-ferrous materials, special ferrous materials and any other materials when indicated by the Lead Engineer – Caltrain or in contract documents.

Manufacturer's test certificates for base material will normally be acceptable. Caltrain reserves the right to select samples for mechanical tests and chemical and/or metallurgical examination.

2.24 TEST CERTIFICATES FOR STEEL MATERIALS

Where a material to be used by the Contractor for fabrication is manufactured overseas, fully-compliant test certificates provided by an independent International Laboratory Accreditation agency or accredited laboratory in US shall be provided to Lead Engineer-Caltrain prior to commencement of fabrication.

The test certificates shall fully comply with the provisions of the nominated standard.

Only fully-compliant test certificates shall be accepted by Caltrain.

The responsibility of ensuring that materials are rigorously tested, to ensure compliance with the relevant material standard, rests with the Contractor who shall insist on being supplied with the requisite test certificates by the steel distributor or supplier.

2.25 TEST CERTIFICATES FOR HIGH STRENGTH FASTENERS

A Test Certificate for each batch of fasteners shall be provided by the supplier. The Test Certificate shall have a statement of compliance assuring that the products are verified and in full compliance with relevant standard.

2.26 CERTIFICATE OF COMPLIANCE

Certificates of Compliance for each batch of items shall be provided by the Contractor to demonstrate that the products have complied with the relevant codes of practice, US standards and prescribed Caltrain requirements.

For compliance certificates issued by a certifier other than the above certifying authorities, evidence must be demonstrated by the contractor that the certifier is qualified and competent to issue and sign compliance certificates.

Certifying authorities/certifiers shall accept full liability and responsibility for the items covered by a certificate or statement of compliance, in the event of failure.

Where acceptance is not achieved, the Contractor shall be liable for any costs associated with further testing or rectification.

2.27 BATCH TESTING

Batch testing shall be performed on no fewer than three (3) fittings for a batch quantity of 100 pieces or less. Where the order quantity is too small to permit this level of testing, and no existing batch test certificate is available, the quality control testing method shall be agreed by the Lead Engineer- Caltrain.

All batch test certificates shall be submitted to the Lead Engineer – Caltrain.

2.28 QUALITY RECORDS

The Contractor shall retain all primary quality records, particularly compliance certificates and test certificates, in accordance with statutory requirements, agreed quality system, contract conditions and relevant US or international standard and make these available at the end of the project or the completion of the supply.

Quality records shall include the results of any system or production audits, tests, observations and measurements including any relevant calculations and analysis.

If otherwise required, records shall be kept for at least five years after the date of issue.

2.29 QUALITY SYSTEM MONITORING

Caltrain reserves the right to monitor the Contractor's Quality System. Monitoring may be by means of surveillance of activities or by formal assessments to gauge the level of adherence by the contractor to the agreed quality system.

The Contractor shall provide any facilities, including access to the Contractor's works which may be required for the monitoring process.

2.30 CONTRACTOR'S CERTIFYING ENGINEER

Where required, the Contractor's Certifying Engineer shall be responsible for the verification and certification of conformance of all items.

Contractor's Certifying Engineer shall have the necessary authority and responsibility to ensure that the Contractor's Quality System has complied with Caltrain specification, relevant US standards, Codes of Practice and State Legislation.

The requirement for verification and certification of items by a Contractor's Certifying Engineer shall be indicated on the relevant or applicable Caltrain specification for materials, on contract documents and when required by Lead Engineer-Caltrain.

2.31 NON-CONFORMANCE

Should non-compliant components be delivered to Caltrain by the Contractor, the Contractor shall be responsible for all expenses necessary to remove the non-compliant components, repair or remanufacture, and return of the components back to Caltrain. Should the non-compliant product be installed into a sub-assembly and already used in Overhead Contact system construction, then the associated costs of removal and reinstallation of the non-compliant component by others shall be deemed to be at the contractor's cost.

Rectification of non-complying components by the contractor shall require the approval of the Lead Engineer-Caltrain.

A non-conformance report shall be completed by the Contractor and shall be issued to the Lead Engineer-Caltrain.

The non-conformance report shall include the details and nature of the non-compliance, proposed action, corrective and preventive plans and completion date. Non-conformance shall be treated according to the Contractor's quality management system.

Any proposed action, corrective and preventive plans and completion date shall be carried out by the contractor only when approved by Lead Engineer-Caltrain. Non-conforming components may be subjected to tests deemed necessary by the Lead Engineer- Caltrain.

All records and certificates in relation to activities from the contractor's approved action, corrective and preventive plans shall be verified and certified by the Contractor's Certifying Engineer (where required) or delegated certifying authority. The contractor shall demonstrate that it can provide effective measures to prevent recurrence of non-conforming components.

2.32 CONFIGURATION CHANGE REQUEST

Where a new or modified product is identified as having possible usage on the Caltrain rail of way, or an existing product is to be acquired from a non-approved Manufacturer, Caltrain shall determine if configuration change request of the product is required.

2.33 TOOLING

A. Provision for Tooling

- a. All tooling including patterns, molds, core boxes, manufacturing jigs, gauges and all other equipment required for manufacture and testing shall be provided by the Contractor.
- b. Irrespective of the type, dimensions and suitability of the tooling, the Manufacturer shall be responsible for the quality and dimensions of the materials produced.
- c. The Manufacturer shall be responsible for the safekeeping of all tooling, packing, etc., whilst in their possession and shall replace any item damaged from any cause. Wear shall be rectified throughout the Contract.

B. Tooling for Spare Parts

- a. Tooling exclusively used for production of proprietary items provided by the Contractor shall become the property of Caltrain to ensure the availability of spare parts. If the Contractor is willing to store and maintain the tool on behalf of Caltrain for future contracts, Caltrain shall be notified in writing. Otherwise, on completion of the Contract, all tooling shall be returned at the expense of the contractor in good order and condition and in the form originally supplied, and in the same crates in which they were received to minimize any damage that is likely to occur in transit. All tooling shall be properly packed, labelled and consigned at the Manufacturer's expense to a Caltrain facility indicated by Lead Engineer – Caltrain, immediately upon completion of production of the individual item concerned.

- b. Tooling which is not required to become the property of Caltrain shall be retained by the Manufacturer in good condition for at least five years beyond the contract completion date for use in the production of further orders.

2.34 MATERIALS, IDENTIFICATION, AND MARKING

All materials shall be clearly marked with:

- the relevant Caltrain item reference number and
- any other markings specified in the relevant authorized Caltrain standard drawings and detailed specifications.

Any completed item, including standard proprietary items, not clearly marked shall be rejected, without further inspection. The Contractor shall at his own expense, when and where directed by the Lead Engineer-Caltrain, rectify poor marking on site or at the point of storage.

Where items cannot be individually marked due to their size, shape or material, or because they are mass-produced manufacture's standard proprietary items, they shall have a punched metal label securely attached or be delivered in bags or boxes adequately marked. Where several items are delivered enclosed in bags or boxes, the quantity contained therein shall be clearly marked.

Where new materials are to be manufactured or supplied and of a type not previously used by Caltrain for its Overhead catenary system, the Lead Engineer- Caltrain will allocate the item reference numbers. The Contractor shall be responsible for obtaining the item reference number prior to the commencement of manufacture of the item concerned.

A. Production and Delivery Program

The successful tenderer shall within seven (7) calendar days of acceptance advice, supply a manufacturing program and a schedule of delivery. The manufacturing program shall show the work breakdown of the various major tasks involved in the production and an indication of the various milestones. The schedule of delivery shall indicate the details and dates of the delivery of the items ordered. Failure to produce a program may result in delayed payment from Caltrain.

B. Notifications of Inspections and Tests

The Contractor shall notify the Lead Engineer- Caltrain in writing advising details of material that have been inspected, certified for compliance (by certifying authorities, where required) and available for further inspection and test. The Lead Engineer- Caltrain shall determine the requirement for further evaluation, inspection and test prior to delivery and despatch of the item(s).

Seven (7) days' notice is required for inspections in Caltrain, Fourteen (14) days elsewhere. To avoid delays, items to be inspected must be grouped together.

The Contractor shall provide all facilities necessary to such Inspectors as for the Contractor's Inspector including notification of inspections and tests.

C. Certificates and Acceptance Condition

The following documents shall be provided by the Contractor prior to product acceptance and configuration change request approval:

a) Test Certificates

Test Certificates shall demonstrate satisfactory results of relevant tests carried out to establish compliance with the relevant standard.

b) Inspection Certificates

The Contractor's Certifying Engineer (where required) or delegated certifying authority shall inspect and certify all components prior to acceptance by Caltrain. All inspection certificates shall be signed by the Contractor's Certifying Engineer and shall be submitted to Caltrain.

c) Certificate of Compliance

Certificates of Compliance shall be issued for each batch of material by a certifying authority, prior to inspections or tests by the Lead Engineer-Caltrain.

2.35 SUPPLY

A. General

All materials shall be supplied properly and securely packed in a method suitable for handling, transport, storage and inspection at the delivery point. Care is to be taken that galvanized steelwork is protected from damage by placing seasoned timber packers between the steelwork item and the transport provider equipment. Should the materials be supplied from overseas manufacturers, then it is mandatory that all relevant conditions and legal requirements be complied with and that all the costs associated in meeting these requirements be included in the tendered price. In particular, timber crates must be fumigated to the set requirement and the supplier shall ensure that the procedure does not produce any adverse effects to the items or the crates.

B. Packaging

Pallets shall be used where the size of the item permits. Pallets and all packaging items are non-returnable. Small parts shall be grouped in bags. The maximum weight per bag shall be 20 kg. The number of items per bag must be divisible by 4. Medium sized items should be contained in groups of 12. Tags impervious to the weather shall be wired to all bags, and shall state the manufacturer's name, purchase order number, relevant item number and quantity of items contained therein.

C. Delivery

Material is required to be delivered on a F.O.G. (Free-On-Ground) basis. It must be assumed that the nominated delivery point has no unloading facilities. It is the responsibility of suppliers to provide the equipment (including the relevant Personal Protective Equipment PPE) and the needed resources for the unloading of materials being supplied. It is required that the nominated site compound or stores be given 24 hours' notice prior to delivery of materials.

No materials will be accepted on the weekends, public holidays or outside normal business working hours, unless otherwise specified by Lead Engineer- Caltrain.

D. Penalty for Delay in Completion / Unsatisfactory Work

Performance Penalty for Delay in Completion / Unsatisfactory Quality of Works applies as follows:

- If the Contractor fails to complete the works within the required time or within any extended time granted in writing by the Lead Engineer - Caltrain, the Contractor shall be liable for consequential damages caused by the delay as stated in the appropriate contract.
- All costs incurred for the return of materials not fit for purpose, and any additional inspection work to ensure the quality of materials shall be charged to the Contractor.

2.36 CONSTRUCTION

Furnish and install all project specific items, included by not limited to the following:

- Furnish and install all OCS pole foundations and guy anchor foundations.
- Furnish and install all OCS poles and pole grounding.
- Furnish and install OCS support systems including brackets, cantilevers, portals, headspan and cross-span supports, small part steelwork and wire pull-off registrations on required poles.
- Furnish, string, tension and insulate messenger and contact wires, including fabrication and erection of hangers and power feeder jumpers and taps.
- Furnish, string, and tension along-track 25 kV ATF feeder conductors.
- Furnish, string and tension the along-track static wire.
- Furnish, string and tension the across-track OCS feeder and ATF connections.
- Furnish and install static wire to track impedance bond connections.
- Furnish and install balance weight anchor assemblies and mid-point anchors, including tensioning and insulation.
- Furnish and install fixed termination anchor assemblies, including messenger and contact wire, ATF and static wire tie-in anchors, tensioning and insulation.

- Furnish and install OCS and ATF feeder cables for all substation/switching stations-to-OCS cable runs.
- Furnish and install rail return cables for all substation/switching station-to-impedance bond/track cable runs.
- Furnish and install OCS disconnect switches with operating mechanisms, associated cables, SCADA connections and personnel safety ground mats (where allocated).
- Furnish and install OCS section insulators.
- Furnish and install phase breaks and associated grounding and connections.
- Furnish and install OCS pole identification and safety signs.
- Furnish and install surge arresters, with associated grounding.
- Furnish mandatory and recommended additional spare parts and special tools in accordance with Section 34 30 96, OCS Spare Parts.
- Furnish and install all necessary temporary material including poles, guys, insulators, feeder/jumper cables, splices, fittings, terminations and miscellaneous items required to enable the catenary system to be constructed in a manner consistent with the existing operation, all civil work sequences and vehicle testing schedules.

The temporary work should incorporate all requirements necessary to construct the OCS in various stages and be coordinated with civil work, the track allocation schedule and/or existing revenue operations.

2.37 O&M MANUALS

Contractor shall provide operating and maintenance (O&M) manuals for OCS equipment.

2.38 WARRANTY OF CONSTRUCTION

The warranty period for all goods, supplies, systems and equipment, except spare parts, shall be two (2) years. Certain OCS assemblies and/or components may require more than the two (2) year warranty; see separate Specification Sections.

The warranty period for spare parts shall either be twelve (12) months from the placement of each spare part into revenue service, or until two (2) years after final acceptance, whichever occurs first. In the event it is necessary to place any spare parts into operation or service prior to the completion of the warranty period, the Contractor warrants and agrees to furnish and deliver free to Caltrain a replacement part to replenish Caltrain's spare parts inventory.

PART 3 - INTERFACE REQUIREMENTS

3.01 DESCRIPTION

- A. This Section includes specifications for the various interfaces between the Work indicated in the Contract Documents and work performed by others, as well as for interfaces between the existing Caltrain Commuter Line and the new OCS work.
- B. The Contractor shall be responsible for the development of all interfaces between the OCS work and work performed by Caltrain Forces and others.
- C. Contractor shall cooperate with and respond appropriately to all interface requests within a period of 15 calendar days following receipt of any request.

3.02 BASIC INTERFACES

3.03 ENVIRONMENT

- 1. Provide OCS materials and equipment that are capable of being operated, stored and maintained without impairment resulting from the impact of the environment of the San Francisco to San Jose area throughout the range of environmental conditions specified in Contract Documents.
- 2. The majority of the work under this Contract is to be performed on, and directly adjacent to, the existing Caltrain Commuter Rail System. The Caltrain normal operating hours are as published on the Caltrain website.
- 3. Schedule all work interfacing with the Caltrain Commuter Rail System with the approval of the Caltrain Operations Department and as required by the Contract Documents to minimize disruption of revenue train service.
- 4. Special Event service schedules may include decreased headway and stacked train, first in - first out, local service, express service and operating hours longer or shorter than those listed on the Caltrain website.

3.04 CALTRAIN INTERFACE

- 1. Conduct all work on the Caltrain Commuter Rail System in full accord with the Caltrain Safety Program Manual. Any conflicts between this Section and the Caltrain Safety Program Manual shall be governed by the latter.
- 2. Permitted access to operating portions of the existing Caltrain Commuter system on a pre-scheduled basis. Access requests shall be submitted in writing, with at least seven (7) days notice, to Caltrain.
 - I. Access requirements will be provided by the Caltrain Operations Department. These requirements will include scheduling, work staging, construction interfacing and the environment under which the work will be accomplished.
 - II. Attend weekly meetings to describe the proposed work plan for the next two weeks. These meetings will be used to coordinate and to resolve issues.
- 3. Any installation or testing which affects existing rail service must be done during the hours as approved by Caltrain and must be completed in sufficient time to

minimize disruptions to normal rail service. Supply sufficient, competent employees and resources to assure restoration of scheduled service within the allotted time. Furnish all equipment such as, but not limited to, warning flags, safety vests, flares, phones, and radios, in accordance with all Caltrain safety and access requirements.

5. Any work crew interfacing with the Caltrain Commuter Rail System operations must be supervised by personnel who have attended and been certified at the Caltrain Track Access Course. All personnel must undergo Railway Worker Protection (RWP) training. Coordinate for times, dates and locations to attend this class.
6. Work which does not affect train operations may be performed, with the authorization of Caltrain, during pre-approved rail operation hours. General Orders/Bulletins, as required, will be issued by Caltrain. Caltrain will furnish the required number of qualified flagmen, watchmen or other employees as may be deemed necessary for safe and continuous operations. Submit to Caltrain at least ten (10) working days prior to implementation, detailed procedures, including an itemized time schedule and breakdown of the labor force. Caltrain has the right to determine the number of qualified flagmen necessary, based on the submitted plans.
7. Provide lighting and electric power, where not specifically provided by others.
8. Caltrain will furnish rail vehicles and vehicle operators, as appropriate, at no cost for the testing as specified in the Contract Documents.

3.05 OPERATING RAIL LINE INTERFACE

1. Submit an installation and cut-over sequence plan for all areas of construction which affect existing Caltrain Commuter Rail operations. Coordinate the work and cut-over schedules with all involved sub-contractors. Submit the installation and cut-over plans within ninety (90) days prior to commencing any field installation work. Include as a minimum, the following:
 - i) Narrative descriptions and schematics for temporary or interim work, methods and materials
 - ii) Descriptions for the implementation and sequencing of tests as specified in Sections 34 30 86, OCS Testing
 - iii) Installation methods and sequencing implementation
 - iv) Narrative descriptions and schematics to maintain existing operations and rail traffic
2. Ground OCS conductors immediately after installation, in a manner subject to approval. OCS conductors are to remain grounded until such time as they are placed in service. Ground in a similar manner, all other aerial conductors within 10 feet of the OCS which are not in service.
3. Coordinate all interface work.

4. Excavations made adjacent to the trackwork area shall not remain open more than forty-eight (48) hours and must be cordoned off and covered to prevent a hazardous condition to the public, Caltrain employees and Contractor personnel. Refer to Specification Section 34 30 33, CIDH Foundations, for requirements associated with drilled excavations adjacent to the trackwork area.
5. Protect at all times, existing equipment and facilities while working on the system. Any damage to the existing system shall be repaired to Caltrain's satisfaction at no additional cost to Caltrain.

3.06 EMU VEHICLE INTERFACE

1. The EMU vehicle and pantograph characteristics will be made available from Caltrain upon request.
2. Train Consist: The standard train for the purpose of testing will consist of 6 EMU cars.
3. The electric locomotive and EMU vehicle dynamic profiles will be provided upon award of Contract.
4. All furnished equipment must be fully compatible with the electric locomotive and EMU vehicles and vehicle equipment, including EMI.

3.07 CALTRAIN COMMUTER RAIL LINE INTERFACES:

Do not disrupt, inhibit or in any way interfere with Caltrain's Commuter Rail revenue service.

3.08 INTERFACES WITH SIGNAL SYSTEM

Coordinate the layout and installation of the OCS structures with the layout and installation of the existing and new wayside signal equipment (i.e., gates, flashers, signal aspects, pushbuttons, etc.).

3.09 INTERFACES WITH TRACTION POWER FEEDERS AND PHASE BREAKS

The OCS installation shall address interfaces with traction power feeders, gantries for 25 kV disconnect switches, and phase breaks.

3.10 NOMENCLATURE

AAR	Association of American Railroads
AC, ac	Alternating Current
Amp or A	Ampere
ANSI	American Nation Standards Institute
Assy	Assembly
ASTM	American Society of Testing and Materials International

AT	Auto-transformer
A.T.	Auto-Tension
AWG	American Wire Gauge
BIL	Basic Insulation Level
BWA	Balance Weight Anchor
CAT	Catenary
C	Celsius
deg	Degree
DC, dc	Direct Current
ea	Each
EMU	Electric Multiple Unit
EN	European Standards
F	Fahrenheit
FDR	Feeder
FTA	Fixed Termination Anchor
FRA	Federal Railroad Administration
FS	Federal Specifications
ft	Feet
F.T.	Fixed Termination
GALV	Galvanized
GRS	Galvanized Rigid Steel
HD	Hard Drawn
Hz	Hertz
in	Inch
kCMIL	Thousand Circular Mils
kJ	Kilojoule
kN	Kilonewtons

kV	Kilovolt
kVA	Kilovolt-Amp
lb	Pound
lbf	Pounds (force)
LF	Linear Feet
LS	Lump Sum
mA	Milliampere
MESS	Messenger
MNHR	Manhour
mm	Millimeters
mo	Month
MPA	Midpoint Anchor
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NESC	National Electric Safety Code
NTP	Notice To Proceed
NIC	Not In Contract
OCS	Overhead Contact System
O&M	Operation & Maintenance
PB	Pushbutton
psi	Pounds Per Square Inch
PVC	Polyvinyl Chloride
QTY	Quantity
ROW	Right Of Way
RMS	Root Mean Square
R,S&I	Rules, Standards and Instructions
SCAT	Simple Catenary Auto Tension

sec	Second
STA	Station, Stationing
SWAT	Single Wire Auto Tension
TBD	To Be Determined
TPSS	Traction Power Substation
UL	Underwriters Laboratories
V	Volt

END OF SECTION

SECTION 34 30 13

OCS BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. This Section includes specifications for furnishing, testing and installation of materials for the electrical work applicable to the construction of the Overhead Contact System (OCS) specified on the Contract Documents and in other Sections.
- B. The work in this Section encompasses the integration and interconnection of various parts, subassemblies, and assemblies of the OCS with each other and with adjacent systems, ensuring seamless compatibility and operational reliability.
- C. The requirements outlined in this Section for OCS basic electrical materials and methods shall be supplemented by other Sections of the OCS specifications, as well as by applicable interfaces with traction power substations, grounding systems, and related infrastructure.

1.02 QUALITY ASSURANCE

- A. All specified materials shall comply with the requirements of applicable Caltrain Specifications, including rigorous material qualification testing, certification for acceptance, and on-site inspections.
- B. Tests shall be conducted on materials and certified by the Manufacturer, including job control testing during shop, factory, and on-site fabrication, as well as final acceptance testing to verify performance under simulated operational conditions.
- C. Quality control functions shall include:
 - 1. Material qualification testing and certification for all components and assemblies.
 - 2. In-progress inspections of work in shops, factories, and on-site.
 - 3. On-site verification of specified work elements, including installation integrity and environmental suitability.
 - 4. The work shall adhere to a comprehensive Quality Management System, ensuring strict compliance with these Specifications and minimizing defects that could impair performance, durability, or safety.

1.03 REFERENCE STANDARDS

- A. American National Standards Institute (ANSI):
 - 1. C80.1, Specifications for Rigid Steel Conduit, Zinc Coated.
- B. American Society for Testing and Materials (ASTM):

1. B633, Specification for Electrodeposited Coatings of Zinc on Iron or Steel.
 2. D149, Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.
 3. D790, Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
- C. National Electrical Manufacturers Association (NEMA):
1. RN 1, Polyvinyl-Chloride Externally Coated Galvanized Rigid Steel Conduit.
 2. WC 7, Cross-Linked-Thermosetting-Polyethylene Insulated Wire and Cable.
 3. WC 8, Ethylene-Propylene-Rubber Insulated Wire and Cable.
 4. WD 1, General Purpose Wiring Devices.
- D. National Fire Protection Association (NFPA):
1. 70, National Electrical Code (NEC).
- E. Underwriters Laboratories (UL):
1. 6, Rigid Metal Conduit.
 2. 83, Thermoplastic-Insulated Wires and Cables.
 3. 467, Grounding and Bonding Equipment.
 4. 1059, Terminal Blocks.
 5. 1581, Referenced Standard for Electrical Wires, Cables and Flexible Cords.
- F. DIN Standards:
1. DIN standards are applicable to hardware and wires as indicated in the Contract Documents.

1.04 SUBMITTALS

- A. Refer to Special Provisions Section 01 33 00, Submittal Procedures for review process.
- B. Submit manufacturer's descriptions, catalog data, shop drawings, product information (including model numbers), installation instructions, and operational instructions for all materials described in this Section that are utilized in the work.
- C. Submit the following OCS arrangements and designs:
 1. OCS Crossover Arrangement
 - a. OCS Jumpers Arrangements

- b. Section Insulator Span Hanger Lengths Calculations
2. OCS Insulated Overlap Arrangement – Single Track
 - a. OCS Jumpers Arrangements
 - b. Overlap Span and Anchor Spans Hanger Lengths Calculations
3. OCS Uninsulated Overlap Arrangement – Single Track
 - a. OCS Jumpers Arrangements
 - b. Overlap Span and Anchor Spans Hanger Lengths Calculations
4. OCS Insulated Overlap Arrangement – Multiple Track
 - a. OCS Jumpers Arrangements
 - b. Overlap Span and Anchor Spans Hanger Lengths Calculations
5. OCS Uninsulated Overlap Arrangement – Multiple Track
 - a. OCS Jumpers Arrangements
 - b. Overlap Span and Anchor Spans Hanger Lengths Calculations
6. OCS Mid-Point Assemblies – Single Track and Multiple Track
 - a. Retainer Cables
 - b. OCS Jumpers Arrangements
 - c. Worst case clearance to in-running contact wire datum
7. Static Wire to Static Wire Across-Track Connection
8. Feeder to Feeder Vertical Elevation Changes at Overhead Bridge Connections

PART 2 - PRODUCTS

2.01 GENERAL

- A. Provide materials and equipment that fit within the designated space, ensuring no interference with other systems or structures.
- B. Where the finish of equipment or material is specified, provide the finish exactly as indicated in the Contract Documents. Where no finish or color is specified, provide the manufacturer's standard finish, suitable for the environment intended. Standard finish must be submitted to Caltrain for review and approval.
- C. Furnish and install materials and equipment designed for satisfactory operation and extended service life under the prevailing environmental conditions, including exposure to weather, vibration, and potential corrosive agents.

- D. All products shall be new, unused, and free from defects. Rebuilt or remanufactured items are not permitted unless explicitly approved.

PART 3 - EXECUTION

3.01 GENERAL

- A. Perform installation work in accordance with applicable requirements of CPUC General Orders (GO) 26D, GO 95, CPUC Resolution SED-2, and NFPA 70.
- B. Install and connect all materials and equipment in strict accordance with the manufacturer's recommendations, ensuring plumb, level, and secure mounting.
- C. Provide adequate slack in wiring for terminations and future adjustments, with no splices except where indicated.
- D. Bundle and secure wires/cables neatly using manufacture approved fasteners, clamps, preventing tension on terminations.

3.02 OCS WIRING DEVICES

- A. Wire Termination: Terminate OCS conductors with approved connectors as indicated on the Contract Documents.
- B. External wiring between electrical equipment shall be accomplished as shown on the Contract Documents and as specified in other Sections.

3.03 TESTING

- A. Perform testing as indicated in the Specifications for OCS related work items.
- B. Certify all tests with manufacturer documentation and on-site verification.

END OF SECTION

SECTION 34 30 33

OCS CIDH FOUNDATIONS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. This Section specifies the requirements for the design, fabrication, supply, and installation of cast-in-drilled-hole (CIDH) foundations for the Overhead Contact System (OCS). All OCS CIDH foundations shall be designed, constructed, and tested in accordance with ACI 336.1, ADSC Standards and Specifications for the Foundation Drilling Industry, and AREMA Manual for Railway Engineering Chapter 8 — Concrete Structures and Foundations, unless otherwise modified herein. These foundations include the following:
1. Cast-in drilled hole (CIDH) Foundations for OCS Poles and Structures
 2. CIDH Foundations for OCS Downguys
 3. Alternate Rock Anchor Foundations for OCS Poles and Downguys, to be provided where subsurface conditions require rock sockets or anchors for stability.
- B. Work Included:
1. Foundation location stake-out and layout, including verification of alignments and offsets from track centerlines.
 2. Augering, drilling, and excavation of CIDH foundations, including handling of groundwater and unstable soils.
 3. Earth and rock excavation, stabilization (e.g., using casings or slurry where necessary), and backfilling, with proper disposal of spoils in accordance with environmental regulations.
 4. Cast-in-place concrete foundations, including formwork, reinforcement, grounding provisions, conduits, anchor bolts, bearing plates, and concrete placement.
 5. Rock foundations and anchors (if required), including formwork, reinforcement, grounding, conduits, anchor bolts, epoxy resin grouting for bonded anchors, and concrete.
 6. Pull-out tests for anchors and rock sockets when required to verify capacity.

1.02 REFERENCE STANDARDS

- A. The following Codes, Regulations, Reference Standards and Specifications apply to work included in this Section:
1. ACI: 222.3R, 301, 304, 305, 306, 315, 318, 336, 347

2. ADSC Standards and Specifications for the Foundation Drilling Industry
3. API RP 13B-1 – Slurry Testing
4. AREMA Manual, Chapter 8 – Concrete Structures and Foundations
5. ASTM: A36, A82, A153, A252, A449, A563, A668, A706, C31, C33, C39, C94, C143, C150, C171, C172, C260, C309, C494, C827, C618, C881, C882, C989, C1582, D149, D570, D635, D638, D695, D790, D1785, D2240, E154 and F1554
6. ASW D1.1 – Structural Welding Code (Steel) and D1.4 (Reinforcing Steel)
7. Caltrans Test Methods 233 – Gamma-Gamma Logging
8. CRSI: 63, 65, Manual of Standard Practice
9. CBC: California Building Code

1.03 SUBMITTALS

- A. Refer to Special Provisions Section 01 33 00, Submittal Procedures for review process.
- B. Qualifications: Proof of Contractor experience with at least three similar projects involving drilled shafts in railroad environments, including soil conditions, shaft sizes, and depths. Include qualifications of welders per AWS DI.I and DI.2. 2. The supervisory personnel in charge of daily operations shall have a minimum of five (5) years of work experience on at least three (3) projects installing drilled shaft foundations. The drilled shaft supervisory personnel shall be present at the site during the entire drilled shaft construction process (i.e. drilling, coring, placing of reinforcement, concreting, etc.) to troubleshoot any problems that may arise during the construction process. Experience must include the direct supervisory responsibility for the on-site construction operations for drilled shafts utilizing the construction techniques required. The equipment operators must have at least three (3) years of work experience on projects using the drilled shaft foundation excavation methods approved for this project.
- C. Manufacturer's Data:
 1. Submit the manufacturer's specifications with application and installation instructions for proprietary materials and items.
- D. Samples:
 1. Submit samples of materials as specified and as otherwise directed, including names, sources, and descriptions.
- E. Material Certificates: Signed by manufacturers and Contractor, certifying compliance with specifications for concrete mix designs, reinforcement, casings, anchor bolts, epoxy grout, and conduits. The material certificates shall certify that each material item meets or exceeds the specified requirements.

- F. Submit product data and manufacturer's installation instructions for specified products.
- G. Submit copies of Certificates of Compliance for each lot of concrete delivered to the site.
- H. Furnish the following information for each CIDH OCS foundation on the As-Built drawings:
 - 1. Structure location number, identify which track foundation is referenced to and measured along-track location by baseline stationing.
 - 2. Final installed distance from top of foundation to individual low rail level of track served and final installed offset from centerline of foundation to centerline of track served.
 - 3. Type of foundation, including installed depth, giving standard reference number from Contract Drawings.
 - 4. Note any dimensional changes and unique or unusual events during excavation or concrete operations.
- I. For each group of foundations, submit the following:
 - 1. Date of pour.
 - 2. Test Reports: Certified reports for concrete compressive strength tests by an accredited laboratory and slurry testing (if used).
 - 3. Delivery ticket number for concrete used or equivalent documentation for concrete prepared on-site.
 - 4. Installation Logs: Proposed forms for recording each foundation, including location, dimensions, elevations, materials encountered, groundwater levels, concrete volume placed vs. theoretical, and any irregularities.
 - 5. Remedial Action Plan: If required for out-of-tolerance or defective shafts, including calculations and drawings sealed by a Professional Engineer.
- J. As-Built Drawings: Within 45 days of completion, submit certified drawings from a registered land surveyor, including final locations, offsets from track centerline, pour dates, depths, and any changes or unusual events. Foundation location shall be within specified tolerances. The contractor is liable for the costs associated with any corrective actions if the foundation is not built to within these tolerances.
- K. Submit Shop Drawings for steel bar reinforcement, bearing plates, anchor bolts, anchor rods. Indicate sizes, spacings, locations and quantities of reinforcing steel, wire fabric, bending and cutting schedules, splicing, stirrup spacing, supporting, and spacing devices. Indicate pertinent dimensions, material types, and arrangement of joints and ties for the formwork. Have Shop Drawings sealed by a professional engineer registered in the State of California, unless otherwise indicated by Caltrain.

- L. Submit detailed description of procedure, equipment, and rig to be used for pull-out tests associated with rock anchored reinforcing bars and rock anchored downguys.
- M. Submit current calibration certificates of all testing equipment to be used for the pull-out tests.
- N. Submit all pull-out test results noting acceptance or failure of tests.
- O. Submit certificates from the mill for manufacture and strength tests for each delivered lot of anchor rods.
- P. Work Plan: Detailed description of construction methods, equipment (including drill rigs with torque capacity and downward force suitable for site conditions), sequence of operations for excavation, casing installation, slurry use and handling (if applicable), reinforcement placement, concrete placement, backfilling and anomaly mitigation procedures. Include provisions for handling groundwater, unstable soils, obstructions, and environmental controls. In addition, submit Mitigation Plans for rejected piles, conforming to ADSC Plan A or B, unless otherwise directed. Address equipment restrictions for rail environments (e.g., low-clearance, high-rail equipped rigs).
- Q. Submit Daily Shaft Logs and slurry test reports.
- R. Submit Trial Batch Reports for wet/slurry placements.

1.04 QUALITY ASSURANCE

Perform all work in compliance with referenced standards and under the supervision of qualified personnel experienced in drilled shaft construction in rail corridors.

- A. Design Mix:
 - 1. Once a design for any class of concrete is issued and approved by Caltrain, it shall not be varied as to source, quantity, quality, grading of materials, or proportioning, or in any other way.
 - 2. All proposed changes shall be accomplished by preparing a new design mix as specified.
 - 3. Provide mix especially suited for various methods of OCS foundation construction.
- B. Sampling and Testing: Sample concrete ingredients prior to use and have them tested by a laboratory for which Caltrain has issued approval, in accordance with the methods specified.
- C. Inspections: Allow for Engineer inspection of excavations prior to reinforcement and concrete placement. Verify bearing strata and cleanliness of shaft bottom.
- D. Construction Tolerances
 - 1. Locate the center of the OCS pole foundations horizontally within the following tolerances:

- a. Along track: Plus or minus 1 foot (for ballasted track areas), or plus or minus 3 inches (for direct fixation track areas).
 - b. Across track: Plus or minus 2 inches (for ballasted track areas), or plus or minus 1 inch (for direct fixation track areas).
 - c. Plumb: Drilled pier out-of-plumb dimensions shall be checked after excavation and before concreting. The maximum tolerance shall be 1-1/2 inches out-of-plumb within each 10 feet of excavation depth. This tolerance applies to the diameter dimension as shown on the plans, and it does not include excavation over-cutting when it occurs. Excavations which exceed this tolerance shall be rejected, backfilled and the drilled pier relocated to an approved location.
2. Locate downguy foundations horizontally within the following tolerances unless otherwise specified:
- a. Along track: Plus, or minus 12 inches relative to the center of OCS pole foundation being anchored (for ballasted track areas), or plus or minus 6 inches relative to the center of OCS pole foundation being anchored (for direct fixation track areas).
 - b. Across track: Plus, or minus 2 inches (for ballasted track areas), or plus or minus 1 inch (for direct fixation track areas).
3. The tops of all foundations and anchors shall be within 1 inch above or below the required levels, as shown in Contract Drawings.
4. Should any of the above tolerances prove to be unachievable due to field conditions, immediately notify Caltrain in accordance with the project specific General Provisions, for further direction.
5. Cut and bend reinforcing steel to conform to dimensions as shown on the Contract Drawings within the following tolerances:
- a. Shear length: Plus, or minus 1 inch
 - b. Stirrups, ties, and spirals: Plus, or minus 1/2 inch
 - c. All other bends: Plus, or minus 1 inch
6. Install OCS pole foundation anchor bolts plumb and within the following tolerances relative to the top of the foundation:
- a. Horizontal: Plus, or minus 1/8 inch off square, the center of which shall meet the tolerance requirements of the foundation.
 - b. Vertical: Plus, or minus 1/4 inch.
 - c. Provide rigid templates for all anchor bolts to ensure correct alignment. Leave template in place for a minimum of three days.

- d. Rotational Tolerance in Relation to Track: As shown on Contract Drawings
7. Conform foundation size to the dimensions shown on the Contract Drawings within a tolerance of plus or minus 1 inch while maintaining nominal concrete cover.
8. If above tolerances are exceeded, Notify Construction Manager immediately for review before proceeding.

PART 2 - PRODUCTS

2.01 CONCRETE

- A. Cement: ASTM C150, normal - Type II or V Portland, gray color, as specified in Section 03 30 00, Cast-in-Place Concrete. Use only one brand of Portland cement throughout the project unless it has been submitted for and received an approval to do otherwise.
- B. Compressive Strength (28 days): 4000 psi.
- C. Maximum aggregate size 1 ½”.
- D. Slump: Maximum as per requirements of concrete application and placement method.
- E. Concrete Mix Requirements for Corrosive Soils: Corrosive soil contains excessive amounts of chlorides and/or sulfates that interact and corrode reinforcing causing concrete voids and spalling. Corrosive soil due to chloride concentrations contains greater than 500 ppm of chlorides. Corrosive soil due to sulfate concentrations contains greater than 2000 ppm of sulfates with a PH less than or equal to 5.5. The following concrete mix measures mitigate corrosive soil interaction with reinforcing:
 1. Minimum compressive strength for structural concrete: 4000 psi minimum with 5000 psi preferred.
 2. Maximum Water/Cement Ratio: 0.49 (AASHTO)
 3. Maximum Slump: Maximum per requirements of concrete application and placement method.
 4. Cement: Type II or V low alkali
 5. Water: Low chloride content from a known controlled supply (i.e., municipal water)
 6. Minimum supplemental cementitious content: 675 Lbs. per CY by adding fly ash and/or Slag cement to decrease permeability and improve workability
 - a. Fly Ash: ASTM C618, Class F
 - b. Slag cement: ASTM C989 Grade 120

7. Chemical admixtures not containing chlorides or sulfides that control water content and inhibit reinforcing reaction and are added during the batching
 - a. Air entraining admixture to improve workability for a low c/w ratio: ASTM C260
 - b. Water-reducing admixture to lower the w/c ratio: ASTM C494, Type F or Type G
 - c. Corrosion inhibitor to retard chloride reaction: ASTM C494, Type S and ASTM 1582
 - d. Rheology modifier to retard chloride reaction: ASTM C494, Type S and ASTM 1582

2.02 FORM MATERIALS

- A. Provide concrete forming in accordance with Section 03 11 00, Concrete Forming and as specified below for types of formworks shown.
- B. Steel Casing (temporary): Galvanized Corrugated Steel Drainpipe, AASHTO M218 and ASTM A929, thickness equal to or greater than 0.064 inch.
- C. Fiberglass forms (for circular formed shapes only): shall be designed specifically for use as a concrete form, diameter as required, removable, multiple uses with proper cleaning of residue.
- D. Treated Paper (cardboard): For circular formed shapes only: shall be designed specifically for use as a concrete form with waterproof surface treatment, diameter as required, removable, one use only.

2.03 REINFORCEMENT

- A. Provide reinforcing steel in accordance with Section 03 20 00, Concrete Reinforcing and the Contract Drawings.
- B. A maximum unreinforced length of 2 feet may be allowed at the base of the foundation with Caltrain's approval.

2.04 CURING MATERIALS

- A. Provide curing material and methods in accordance with Sections 03 30 00, Cast-in-Place Concrete and 03 35 00, Concrete Finishing.

2.05 ANCHOR RODS AND ANCHOR BOLTS

- A. High-strength carbon steel bolts; ASTM F1554, Grade 55 S1, unless otherwise noted on the Contract Drawings. Bolts shall have over-tapped threads in accordance with AISC requirements for UNC Series. Provide certificates from the mill for manufacture and strength tests for delivered lot. Anchor bolts and anchor rod assemblies shall be hot dip galvanized. Nuts shall comply with ASTM A563, Grade C, hot dip galvanized, over-tapped threads in accordance with AISC requirements for UNC series. Washers

shall comply with ASTM F436, Type 1, hot dip galvanized.

- B. Anchor Bolt Template: ASTM A572, Grade 50, Hot dipped galvanized.
- C. Galvanizing shall comply with ASTM A153.

2.06 CLEVIS CONNECTOR AND COUPLER SLEEVE

- A. Forged steel; ASTM A668.
- B. Galvanizing complying with ASTM A153.

2.07 GROUND WIRE

- A. Ground wire, where required, shall be ASTM B3 annealed, soft-drawn, bare copper, unless otherwise indicated, of class "B" strand, with 98 percent conductivity.
- B. The size of grounding cables shall be as shown on the Contract Drawings. Where not indicated, grounding cables shall conform with the requirements of the National Electrical Code. Minimum size shall be 4/0 AWG.

2.08 PVC CONDUITS

- A. Comply with Sections 26 05 33.13, Conduit for Electrical Systems and Caltrain Standard Drawings (SD-W5000 series).

2.09 NON-SHRINK GROUT

- A. ASTM C150 pre-mixed compound with non-metallic aggregate, cement, water reducing and plasticizing agents; capable of minimum compressive strength of 3500 psi. Shrinkage shall be in accordance with ASTM C827. Other types may be used subject to Caltrain's approval.

2.10 EPOXY- RESIN GROUT

- A. Where rock embedment for Down guys and reinforcement bars is required, the embedment shall be by means of cementing the anchor or re-bar into a drilled hole, which shall be filled with epoxy-resin grout after the anchor or re-bar is inserted. The epoxy-resin grout may be mixed at the site and poured into the holes or may be provided in prepackaged cartridges for insertion into the anchor hole.
- B. Epoxy-Resin Grout: 2 component, mineral-filled, epoxy-polysulphide polymer complying with FS MMM-G-650, Type I or II, Grade A. Compressive strength of the mixed and cured resin shall be not less than 14,000 psi when tested in accordance with ASTM C39.
- C. When the pre-packaged option is selected, provide resin cartridges with a casing constructed of a saturated polyester providing optimum resistance to moisture but easily ruptured to enable complete mixing and integration with hole side walls during installation and containing two distinct fractions of unsaturated polyester resin and catalyst without an intervening mechanical membrane. The resin shall be high strength polyester with non-reactive inorganic filler. The catalyst shall contain peroxide with a non-reactive inorganic filler. The materials shall have thixotropic and

viscous properties to permit adequate mixing of the materials by manipulating the embedded rod or bar. The shelf life of the epoxy-resin shall be not less than six months. Gel and cure time shall be within 10 minutes after completion of installation.

- D. Products offered by manufacturers complying with the requirements for epoxy-resin type grout include the following:
 - 1. 32 Hi-Mod.; Sika Chemical Corp
 - 2. Epoxite; W.R. Grace
 - 3. A-H Poly-Epoxy Bonding #100; Anti-Hydro Waterproofing Company
 - 4. Euco Epoxy System 452; Euclid Chemical Company
 - 5. Polytops 40; Chem-Masters Corporation
 - 6. Sonobond; Sonneborn-Contech
 - 7. Probond ET-150; Protex Industries

2.11 BACKFILL MATERIAL

- A. Provide backfill material in accordance with Section 31 00 00, Earthwork.

2.12 SLURRY DRILLING FLUID

- A. Slurry drilling fluid is for use when selected as an optional drilling method using a liquid slurry to displace ground water and to maintain sides of excavation in uncased drilled holes. The slurry drilling fluid shall consist of water mixed with very fine-grained solids and beneficial admixtures, meeting the requirements of ACI 336.1.

PART 3 - EXECUTION

3.01 PREPARATION

- A. The installation of all OCS pole and downguy foundations shall be scheduled and performed so that each pole shaft excavation has the entire concrete placement completed the same day as the excavation and drilling operations are completed. At the end of a shift, if concrete is not placed in the foundation, temporary casing with a cover will be used to support the excavation. All required foundation materials including reinforcement, anchor bolts, rods, conduits and bonding and grounding hardware shall be ready and available for placement without delay. An exception to this requirement shall be allowed for as described in Part 3.02.K.5 of this Section.
- B. Do not allow external vibration or excessive wheel loads within the immediate vicinity of any excavation. Maintain sides of excavations always stable.
- C. Identify lines, levels, and datum for required foundation work.
- D. Without exception, locate and stake out all foundation locations and determine all foundation elevations so that the positions are verified prior to installation. Any locations having potential clearance problems shall be reported without delay.

- E. Protect excavations by shoring, bracing, temporary casing or other methods required to prevent cave-in or loose soil from falling into the excavation.

3.02 EXCAVATION

- A. Excavate all material required for installation of CIDH OCS foundations to the designed embedment depth.
- B. Unauthorized excavation consists of removal of materials beyond indicated subgrade elevations or dimensions. Remedial work shall be performed to correct the situation.
- C. General water control: Prevent surface and/or subsurface water from flowing into excavations and from flooding project site and surrounding areas.
 - 1. Do not allow water to accumulate in excavations. Continually remove water to prevent softening of foundation bottoms, undercutting footings or slabs, and soil changes detrimental to stability of subgrades and foundations.
 - 2. Provide and maintain all dewatering system components necessary to convey water away from excavations to approved collecting or run-off areas.
- D. In excavating (by mechanical or hand methods), do not disturb the bottom of the excavation. Trim bottoms to required lines and grades leaving a solid base to receive concrete. Excavations shall be stable and shall not affect the integrity of adjacent structures.
- E. When excavation has reached the required dimensions and below-grade elevations, provide notification to allow for inspection of the conditions. If unsuitable bearing materials are encountered at the required subgrade elevations, cease all work on the foundation and provide notification for further direction.
 - 1. Unsuitable material is defined to include cinders, organic soil, highly plastic clay, soft or saturated soil, vegetation, or other deleterious substance having poor bearing capacity. Unsuitable material is further defined in Section 31 00 00, Earthwork.
 - 2. If the excavation for an OCS pole foundation or downguy is oversized in any dimension, the additional excavated space shall be filled with concrete. The use of other types of backfill is prohibited.
- F. Drilled pier foundation excavations shall be made by mechanical auger or rotary drill, cased or uncased. Augers shall be of a vented design to prevent suction in the hole during bit removal. Excavated holes shall be of the size required for placing concrete directly against the excavated undisturbed vertical soil surfaces, obtaining sizes shown on the Contract Drawings.
- G. Select a method of excavation at each foundation site which meets all contract requirements and site conditions. Make use of all existing subsurface information to determine the nature of subsurface soils and presence of ground water, by selecting an excavation procedure that will permit placement of the reinforced concrete pier foundation in a cleared water-free excavation, or a slurry-filled excavation.

- H. Select the methods and equipment to be used to excavate the drilled pier foundation and maintain the excavation in a manner suitable to install all reinforcement, anchor bolts and deposition of concrete. Excavations which do not meet contract requirements shall be backfilled and new excavations made at the Contractor's expense. Drilling excavation methods which are unsuccessful due to soil cave-ins or presence of ground water shall utilize a different method more suited to conditions which will obtain excavated holes that meet all specified conditions.
- I. If, after a drilled pier foundation site has been excavated, the excavated hole cannot be kept free of standing ground water or the side soils are loose and caving in, Caltrain retains the right to issue a rejection for the excavation for use and deny payment for the work. The excavation shall be backfilled, and the required foundation site shall be relocated away from the rejected hole. The drilling/excavation procedure shall be modified as required to obtain acceptable holes.
- J. In all cases, each drilled pier excavation must be free of standing ground water, and loose soil at the bottom which forms a layer more than 3" thick prior to placement of the reinforcement and concrete. A slurry drilling fluid may be used to displace the ground water and stabilize the sides and bottom of the hole. When slurry drilling fluid is used, provide an easily manipulated feeler/measurement rod which can be used to verify depth of hole, plumb tolerance, width at bottom and condition of bottom surface.
- K. When solid rock is encountered during excavation, an alternate style foundation in accordance with the criteria shown on the Contract Drawings shall be provided.
 - 1. Rock shall be defined as a mass of solid aggregate of one or more minerals or mineraloids. Weathered or decomposed hardened matter that is more than 1/3 soil shall not be considered rock.
 - 2. Excavate and remove rock by hand or mechanical methods. Explosives are not permitted.
 - 3. Cut away rock in the excavation to form level or otherwise acceptable bearing surface.
 - 4. Remove shale layers to provide a sound and unshattered base for foundations and anchors.
 - 5. Do not leave rock surfaces, which are intended to serve as foundation bearing areas, exposed for more than 48 hours prior to concreting. Where the rock surface is subject to rock anchor testing that is scheduled to occur more than 48 hours after initial exposure, cap the rock surface with 2 to 3 inches of concrete after installation of the rock anchor. All open excavations shall be protected as described in Section 31 00 00, Earthwork.
 - 6. In all cases, the bearing surface of the rock foundation shall be clean and free of any rock spoil, soil, and water.
- L. In the urban environments along the corridor, be responsible for conducting the work such that the following public space concerns are addressed:

1. Removal and replacement of existing concrete, roadway surfaces, sidewalks, pavers, curbs, and existing slabs. Return to like-new previous condition in accordance with applicable City and township requirements.
2. Protection of open excavations and holes, including warning tape, fencing, and steel capped cans, to prevent public from falling into an open hole or excavation. Follow all applicable City and township requirements for protecting the public.
3. Removal of spoils from all roadways, sidewalks, and existing areas.

3.03 FABRICATION AND PLACING REINFORCEMENT, ROCK ANCHORS AND ANCHOR BOLTS

- A. Reinforcement for OCS foundations and anchors shall be fabricated and installed as specified in Section 03 20 00, Concrete Reinforcing, and as follows:
 1. Bar reinforcement for drilled pier foundations shall be placed, positioned and secured to prevent movement prior to any concrete placement. In no case shall bars, prefabricated bar cages or anchor bolts be pushed or lowered into fresh concrete which has been placed in an excavated hole prior to reinforcement placement. The reinforcement assembly shall be fitted with devices which assure that the required concrete cover over bars will be obtained.
- B. Provide spare nuts and washers for the OCS pole anchor bolts which comply with these Specifications. The spare nuts and washers shall consist in quantity of 5% of the amount installed of each size, rounded higher to the next full number of nuts or washers. These spare nuts and washers shall be delivered to Caltrain at a location specified by Caltrain.
- C. Prior to final installation of reinforcing bar rock anchors, all overburden of soil, decomposed rock and layered unstable rock shall be excavated to obtain a surface of stable foundation rock. The pattern of anchor holes shall be accurately marked on the rock surface. Anchor holes shall be drilled with equipment that will provide an anchor hole diameter which is in accordance with the epoxy resin grout manufacturer's recommendations.
 1. Insert the proper volume of epoxy resin grout required in accordance with the manufacturer's recommendations for the anchorage conditions, into the drilled hole.
 2. A pre-packaged epoxy resin grouting system may be used in which tubes of the packaged material are inserted into the drilled hole before the anchor is inserted. Follow manufacturer's instructions for installation of grouting system and reinforcing rods.
 3. In-place pull-out test:
 - a. Perform testing in the presence of Caltrain to verify that the specified tension can be sustained by the reinforcing bar and anchorage without yield of the steel or rock or slip of the anchor and to check the grouting procedure and the grout strength.

- b. Conduct the pull-out test as follows:
 - i. Test all Grouted Rock Anchors for down guys.
 - ii. Test one anchored reinforcing bar, selected at random, in the first rock pole-type foundation constructed and in other foundations as directed.
- c. Provide and maintain in good working condition the equipment to be used for performing pull-out tests.
- d. Provide pull-out test equipment consisting of a suitably sized hollow ram jack, adjustable bearing truss for aligning the direction of pull with the centerline of the bar, an extension for attaching the jack to the bar, a hydraulic pump with a gauge calibrated to read directly in pounds for the ram being used, a dial gauge which reads in increments of 0.001 inch over a range of at least one inch, a magnetic or independent dial gauge mounting, cribbing and all other necessary accessories. Submit procedures and details of testing rig and equipment prior to any tests.
- e. Test rock anchored bars not earlier than recommended by the epoxy manufacturer, nor later than 72 hours after installation into rock. Tests shall be completed and accepted prior to construction of the concrete foundation.
- f. Pull-out test loads shall be calculated based on 30,000 pounds per square inch of cross-sectional area of the steel bar being tested, and actual jacking pull-out load will vary with the diameter of the rod or anchor bar being tested. The pull-out test load shall be applied and held constantly for one hour and then released in gradual increments. A record of any bar movement shall be made by measurement of bar deflection or extension, by applying the distance measurement gauge to a fixed point on the test bar. The fixed point shall be located at or near the top of the bar, but not on the jack grips. The movement gauge shall be mounted independently of the jacking frame and crib.
- g. The reaction bearing zone of the testing rig shall be a minimum of 5 feet horizontally from the point where the tested bar is grouted into rock.
- h. The tested bar or anchor shall have passed the test if the following criteria are met or exceeded:
 - i. The steady load test pressure, expressed in units of force, did not vary more than 5% below the calculated test load during the one-hour test period.
 - ii. The movement of the fixed point on the test bar or anchor did not exceed 0.2 inches at the test conclusion.

- iii. All other test functions were normal, and no equipment failures occurred.

When a tested anchor or bar fails the pull-out test, it shall be rejected from further use. In the event of such a failure, evaluate the cause of the failure, develop a remedial action, install another anchor at a site and retest. Grouted bars or anchors which are successfully tested shall be accepted and incorporated into the foundation or anchor structure construction.

3.04 INSTALLING CONDUITS

- A. Install electrical conduits and stub-ups in OCS foundations, if required, as shown on the Contract Drawings.
- B. Use the size, type and general routing as shown on the Contract Drawings, including but not limited to Traction Power, Traffic, Civil, Roadway, Electrical, Lighting, Signals and Utilities.
- C. Install conduit bends in accordance with NEC.
- D. Support conduits to prevent movement, distortion, and damage during placement of concrete.
- E. At all stages of the work, exercise care to prevent foreign materials from entering the conduits.
- F. The ends of conduits shall be capped and installed with pull cords prior to placement of concrete.
- G. The ends of field cut conduits shall be reamed to remove rough edges. The ends of PVC conduits that are to be joined shall be coated with conduit cement for a length equal to the depth of the coupling or other fitting, to ensure a watertight connection.

3.05 PLACING CONCRETE

- A. Provide notification to Caltrain a minimum of 24 hours prior to commencement of all concreting operations at each foundation.
- B. General: Place concrete in compliance with the practices and recommendations of ACI 301, and as herein specified.
 - 1. Deposit concrete such that no cold joints or planes of weakness are produced within the foundation. Perform concrete placing at such a rate that concrete being integrated with fresh concrete is still plastic. Deposit concrete as nearly as practicable to its final location to avoid segregation due to rehandling or flowing. Do not subject concrete to any procedure that will cause segregation. Place concrete in a compact, monolithic mass, using a method that prevents washing of concrete.
 - 2. Use of vibrators is not required if concrete is placed in one lift, but multiple lifts require the use of a pencil vibrator to consolidate the top 3 to 6 inches of the previous lift.

3. Mask the exposed bolt threads with the masking tape to avoid concrete setting on the holding down bolt's threads.
4. Screed concrete to the proper level to avoid excessive skimming or grouting.
5. Do not use concrete that becomes nonplastic and unworkable, or does not meet the required quality control limits, or that has been contaminated by foreign materials. Do not use retempered concrete. Remove rejected concrete from the project site and dispose of it at the Contractor's expense, in accordance with the requirements of applicable regulatory agencies and project specifications.
6. Particular emphasis shall be given to the placement method type within a shift in the detailed description of pile construction procedure. Clearly identify and describe how to place concrete based on the method of installation.
7. A dry hole is defined as:
 - a. A hole that accumulates no more than 12 inches of water in the bottom of the drilled hole during a period of 1 hour without any pumping from the hole during the hour.
 - b. Has no more than 3 inches of water in the bottom of the drilled hole immediately before placing concrete.
8. Concrete Placed in a Dry Hole:
 - a. Have a nominal slump of 4 to 6 inches for placement by hopper method:
 - i. Using a trunk-equipped hopper or pump pipe inserted into the excavated hole as low as possible allowing concrete to fall freely into the pier in a vertical direction not more than 6-feet and not impacting the sides of the shaft or the reinforcement cage.
 - ii. Vibrate concrete in the upper 15-feet when using hopper method. Emphasis should be given at the point where the concrete pour is momentarily halted.
 - b. Have a nominal slump of 7 to 9 inches for placement by tremie method:
 - i. Using a tremie tube, place the tip of the delivery tube within 6-inches of the bottom of the hole until 5-feet of concrete has been placed. Maintain the embedment of the tip at least 5-feet below the top surface of the concrete. Do not rapidly raise or lower the delivery tube.
 - ii. Placing of concrete must be a continuous operation for each concrete placing operation at each pile.
 - iii. Vibrating concrete is not required.

- iv. The nominal penetration requirements of CSS Section 90 do not apply to concrete placed under tremie method.
9. Concrete Placed under Slurry:
- a. For all CIDH concrete piles except for piles constructed in dry holes or dewatered holes without the use of temporary casing to control groundwater or as in accordance with Section 2.12 of this specification. Placing of concrete must be a continuous operation for each concrete placing operation at each pile.
 - b. Have a nominal slump of 7 to 9 inches for placement by tremie method:
 - i. Using a tremie tube, place the tip of the delivery tube within 6-inches of the bottom of the hole until 5-feet of concrete has been placed. Maintain the embedment of the tip at least 5-feet below the top surface of the concrete. Do not rapidly raise or lower the delivery tube.
 - ii. Vibrating of concrete is not required.
 - iii. The nominal penetration requirements of CSS Section 90 do not apply to concrete placed under tremie method.
10. To control caving, you may enlarge portions of the hole, backfill with concrete or slurry cement backfill, and re-drill the hole to the required diameter. Backfill material at enlarged piles must be chemically compatible with concrete and steel, be drillable, and have the necessary strength required for conditions.
- C. Provide bracing to ensure stability of formwork. Strengthen all formwork which is liable to be overstressed by construction loads.
- D. Application of Form Release Agent:
- 1. Apply form release agent on formwork in accordance with manufacturer's instructions. Apply prior to placing reinforcing steel, anchoring devices and to embedded items.
 - 2. Do not apply form release agent where concrete surfaces are scheduled to receive special finishes or applied coverings which may be affected by the agent. Soak contact surfaces of untreated forms with clean water. Keep surfaces damp prior to placing concrete.
- E. Inserts, Embedded Parts and Openings:
- 1. Provide formed openings where required for work bedded in or passing through concrete.
 - 2. Coordinate work of other Sections in forming and setting openings, slots, recesses, chases, sleeves, bolts, anchors, conduits, and other inserts as

shown on the Contract Drawings.

3. Install accessories in accordance with the manufacturer's instructions, level and plumb. Ensure items are not disturbed during concrete placement.

F. Concrete Mixing:

1. Concrete may be mixed at an approved batch plant, or it may be transit-mixed. Batch plants shall comply with the requirements of ACI 304, with sufficient capacity to produce concrete of the qualities specified to meet the construction schedule or shall be in accordance with approved concrete mixing operations associated with mobile plant mixing. All plant facilities shall be subject to inspection and approval by Caltrain and shall comply with Section 03 30 00, Cast-In-Place Concrete.

G. Placing Concrete into Forms: Comply with Section 03 30 00, Cast-in-Place Concrete, as applicable.

H. Hot Weather Placement:

1. When hot weather conditions exist that would seriously impair the quality and strength of concrete, place concrete in compliance with ACI 305.

I. Cold Weather Placing:

1. Protect all concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures, in compliance with the requirements of ACI 306.
2. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators.

J. Ensure that all reinforcement, inserts, and embedded anchors are not disturbed during concrete placement.

1. Before placing concrete, clean reinforcement of dirt, oil, ice, or coatings which could reduce or destroy the bond with concrete.
2. Place, support, and secure reinforcement against movement and displacement, such that it does not deviate from final alignment or measurement.
3. Provide enough support for the required strength to carry reinforcement. Do not place reinforcing bars more than 2 inches beyond the last leg of any continuous bar support.
4. Threads of anchor bolts shall be adequately protected prior to, during and after placement of the concrete.

K. Finish of Formed Surfaces (see also Section 03 35 00, Concrete Finishing):

1. Smooth Form Finish:

- a. Provide as-cast smooth form finish for formed concrete surfaces that are to be exposed to view.
 - b. Produce smooth form finish by selecting form material to impart a smooth, hard, uniform texture and arranging them orderly and symmetrical with a minimum of seams. Repair and patch defective areas, with all fins or other projections completely removed and smoothed.
- L. Form Removal:
1. Provide notification at least 24 hours prior to removing formwork.
 2. Formwork supporting concrete, to include sides of foundations above ground level, may be removed after 24 hours of curing, provided that the concrete is not damaged during formwork removal.
 3. All concrete damaged during formwork removal shall be repaired at Contractor's expense.
- M. Withdrawal of Steel Casing:
1. Where temporary steel liners are used to support the excavation of drilled pier walls, withdraw the liners while the concrete is being placed. Remove the steel casing in a manner so that the lower edge of the steel casing will always remain a minimum of three feet below the surface of the concrete as poured to prevent water from entering the casing from the bottom or collapse of earth walls. Vibrate concrete during withdrawal of the steel casing.
- N. Patching:
1. Patching Defective Areas:
 - a. Repair and patch defective areas with cement mortar immediately after removal of forms.
 - b. Cut out honeycomb, rock pockets, voids over 1/2-inch diameter, and holes left by tie rods and bolts, down to solid concrete but in no case to a depth of less than one inch. Make edges of cuts perpendicular to the concrete surface. Before placing the cement mortar, thoroughly clean, dampen with water and brush-coat the area to be patched with neat cement grout. Approved proprietary patching compounds may be used.
 - c. For surfaces exposed to public view, the patching mortar shall match the color of the surrounding concrete. Provide test areas at inconspicuous locations to verify mixture and color match before proceeding with the patching. Compact mortar in place and strike off slightly higher than the surrounding surface.
 - d. Repair methods not specified above may be used, subject to approval.

- O. Schedule of Formed Surfaces:
 - 1. Smooth surface finish for all OCS structure foundations.

3.06 FIELD QUALITY CONTROL

- A. Field inspection will be conducted by Caltrain and/or their representatives.
- B. Quality Control testing during construction shall be performed as follows:
 - 1. Sampling Fresh Concrete: ASTM C172, except as modified for slump, to comply with this specification.
 - 2. Slump: ASTM C143; one test for each concrete load at point of discharge; and one for each set of compressive strength specimens.
 - 3. Compression Test Specimens: ASTM C31.
 - 4. Concrete Temperature: Test daily when air temperature is 40° F and below, and when 80° F and above; and each time a set of compressive test specimens is made.
 - 5. Compressive Strength Tests: ASTM C39.
 - 6. Testing laboratory shall report tests results in writing to Caltrain. Reports of compressive strength tests will contain the project identification name and number, date of concrete placement, name of Contractor, name of concrete testing service, concrete type and class, pole number(s) of foundation(s) and location(s) of downguys poured with each batch, design compressive breaking strength and type of break for both 7-day test and 28 day test.
- C. Additional Tests:
 - 1. The testing services shall make additional tests of in-place concrete when test results indicate the specified concrete strengths and other characteristics have not been attained in the structure. The testing service shall conduct tests to determine the strength and other characteristics of in-place concrete by compression tests on cored cylinders complying with ASTM C42, or by load testing specified in ACI 318, or other acceptable non-destructive testing methods, as directed. The Contractor shall pay for such tests conducted, and any other additional testing as may be required, when unacceptable concrete is verified.
- D. Evaluation of Quality Control Tests:
 - 1. Do not use concrete delivered to the final point of placement which has slump outside the specified values.
 - 2. Compressive strength tests for laboratory-cured cylinders will be considered satisfactory if the averages of all sets of three consecutive compressive strength tests results are equal to or exceed the 28-day design compressive strength of the type or class of concrete; and no individual strength test falls

below the required compressive strength by more than 500 psi.

3. If the compressive strength tests fail to meet the minimum requirements specified, the concrete represented by such tests will be considered deficient in strength and rejected for inclusion in the work.

E. Foundation Grounding System Tests:

1. Perform electrical resistance testing of the OCS foundation grounding system. Any incorrect grounding arrangements shall be repaired and corrected.

3.07 ADJUSTING AND CLEANING

- A. Clean forms to remove foreign matter as installation proceeds.
- B. Do not use water to clean out completed forms unless formwork and construction proceed within a heated enclosure. Use compressed air or other methods for which an approval has been received to remove foreign matter.
- C. Concrete not conforming to required levels and lines, details, and elevations shall be replaced at no cost.

3.08 PROTECTION

- A. Protect finished work until final acceptance. Special precautions shall be employed to ensure that above ground portions of completed foundations (including the anchor bolts, anchor rods and concrete finish) are not struck or damaged by other equipment working adjacent to the foundations, including equipment employed by sub-contractors and other Caltrain Contractors (such as earthmoving equipment, dump trucks, ballast delivery trucks, rail placement equipment, etc.). Submit proposed method of protecting the OCS foundations review prior to the construction of any OCS foundations.
- B. Immediately after placement, protect exposed concrete from premature drying, excessively hot or cold temperatures, and mechanical injury.
 1. Protect freshly placed concrete from premature drying and at temperatures at or above 80° F and at or below 40° F and maintain without drying at a relatively constant temperature for the period necessary for hydration of the cement and proper hardening of the concrete.
 2. Begin final curing procedures for exposed concrete immediately following hydration of the cement and proper hardening and before the concrete has dried. Continue final curing for at least 7 days and in accordance with ACI 301. Avoid rapid drying at the end of the final curing period.
- C. Temperature of Concrete During Curing:
 1. When the atmospheric temperature is 40° F or below, maintain a homogeneous concrete temperature between 50° F and 70° F continuously throughout the final curing period. When necessary, make arrangement before concrete placing for heating, covering, insulation or housing as

required to maintain the specified temperature and moisture conditions continuously for the concrete curing period. Provide cold weather protections complying with the requirements of ACI 306.

2. When the atmospheric temperature is 80° F and above, or during other climatic conditions which will cause too rapid drying of the exposed concrete, plan before the start of concrete placing for the installation of wind breaks or shading, and for fog spraying, wet sprinkling, or moisture-retaining covering. Protect the exposed concrete continuously for the concrete curing period. Provide hot weather protection complying with the requirements of ACI 305.
3. Maintain concrete temperature as uniformly as possible and protect from rapid atmospheric temperature changes. Avoid temperature changes in concrete which exceed 5° F in one hour and 50° F in a 24-hour period.

D. Protection from Mechanical Injury:

During the curing period, protect concrete from damaging mechanical disturbances, including load stresses, heavy shock, excessive vibration, and from damage caused by rain or flowing water. Protect all exposed finished concrete surfaces from damage by subsequent construction operations.

- E. Drilled shafts may be rejected by the Construction Manager because of damage, failure to advance through obstructions, mislocation, misalignment, or failure to install the drilled shaft to the proper bearing stratum. The Contractor shall submit a written plan of action to the Construction Manager for approval, showing how to correct the problem and prevent its reoccurrence. The drilled shaft shall be repaired, augmented or replaced to the satisfaction of the Construction Manager. To mitigate and/or to remedy unaccepted drilled shafts, the Contractor may be required to provide additional drilled shafts or supplement drilled shafts to meet specified requirements at no cost to Caltrain.

END OF SECTION

SECTION 34 30 39

OCS METAL POLES AND SMALL PART STEELWORK

PART 1 - GENERAL

1.01 DESCRIPTION

This Section includes specifications for the design, fabrication, furnishing, delivery, installation, and testing of OCS poles and small part steelwork for the Overhead Contact System (OCS) as shown on the Contract Drawings and specified herein.

The poles shall consist of wide flange, square tube (HSS), tapered tubular steel types, and non-tapered round types. All poles shall conform to the type and size requirements shown on the Contract Drawings.

All round pole shafts shall be smooth (not multi-faceted) as indicated on the Contract Drawings.

All poles shall be hot-dip galvanized regardless of finish treatments. Weathering steel is not permitted on the corridor because of the marine, salt-fog environment and the instability of protective rust layer under such conditions. See paragraph 2.1.D, this section, for galvanizing of OCS poles and small steel parts.

1.02 REFERENCE STANDARDS

Pertinent provisions of the following latest edition standards shall apply to the work of this Section, except as they may be modified herein, and are hereby made a part of this Specification to the extent required:

- A. American Society for Testing and Materials (ASTM):
1. A36/A36M-19, 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. A143, Standard Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedures for Detecting Embrittlement.
 5. A153, Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware.
 6. A283/A283M-24, Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.
 7. A354, Specification for Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners.

8. A370, Standard Test Methods and Definitions for Mechanical Testing of Steel Products.
 9. A500, Specification for Cold Formed Welded and Seamless Carbon Steel Structural Tubing.
 10. A563, Specification for Carbon and Alloy Steel Nuts.
 11. A572, Specification for High-Strength, Low-Alloy Columbium-Vanadium Structural Steel.
 12. A595/A595M-22, Specification for Steel Tubes, Low-Carbon, or High-Strength Low-Alloy, Tapered for Structural Use.
 13. A992, Specification for Structural Steel Shapes.
 14. E1316, Standard Terminology for Nondestructive Examinations.
 15. B6, Specification for Zinc.
 16. E709, Standard Guide for Magnetic Particle Testing.
 17. F3125 GRADE A325, Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength.
 18. F3125 GRADE A490, Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength.
 19. F436, Specification for Hardened Steel Washers.
 20. F593, Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
- B. American Institute of Steel Construction (AISC)
1. Specifications for Structural Joints Using ASTM F3125 Grade A325 or A490 Bolts.
 2. Specification for Structural Steel Erection.
- C. American Welding Society (AWS)
1. D1.1, Structural Welding Code.

1.03 SUBMITTALS

- A. Refer to Special Provisions Section 01 33 00, Submittal Procedures for review process.
- B. Submit the manufacturer's specifications and installation instructions for Caltrain review for all components in this Section. Additionally, submit specifications and installation instructions to Caltrain for records purposes.

- C. Shop Drawings: Submit shop drawings, under seal of a Professional Structural or Civil Engineer registered in the State of California, for review giving complete information necessary for the fabrication of the poles and supporting calculations. The shop drawings shall be to scale and shall indicate all fittings, holes, and accessories, and shall also give location, sizes, and types of all welds.
- D. Submit certificates of compliance or certified laboratory test reports demonstrating compliance of all raw materials and fabricated products prior to fabrication.
- E. Proofs of Compliance: Submit for review, prior to commencing fabrication, the manufacturer's certificates of compliance, or certified laboratory test reports. The reports shall demonstrate the compliance of all raw materials and fabrication products. Included shall be a listing of all standards designated by the manufacturer, as indicated.
- F. Test Reports: Furnish copies of test reports of all factory tests as required by these Specifications and referenced standards. Submit certified copies of the laboratory test reports within five days after completion of each test or series of tests.
- G. On shop drawings, indicate welded connections using standard AWS welding symbols. Indicate net weld lengths, and sizes.
- H. Submit an authentic sample of any component as indicated on shop drawing reviews, when so requested, or as required in the Specifications. All samples shall be identified with a tag label of suitable material, wired to the sample.
- I. For OCS poles in station areas, submit all specifications, installation instructions, shop drawings, certificates, test reports, samples, and other submittals to Caltrain for review and transmittal to the local municipal authority
- J. Welding: Submit specifications for welding procedures and processes, certificates of qualifications of welders, welding operators, tackers, and welding inspectors for acceptance, together with the installation instructions for all components in this Section in accordance with AWS D1.1.
- K. Pole Deflection Test Procedure: Submit a test procedure for approval, prior to testing any poles. The test procedure shall include method of application of loads, recording devices, calibration of devices, and any other information deemed pertinent. Parameters demonstrated shall include load at maximum deflection and deflection at maximum loading. The test procedure shall be signed and sealed by a qualified Professional Engineer registered in the State of California.

1.04 QUALITY ASSURANCE

- A. Perform the Work included in this Section in strict accordance with the requirements of Section 01 43 00, Quality Control and Assurance.
- B. Qualifications for Welding Work

1. Quality of welding processes and welding operations shall be in accordance with AWS D1.1 and Quality Plan.
 2. Provide certifications that welders employed have satisfactorily passed AWS qualification tests within the previous 12 months.
 - a. Provide re-certification and retesting of welders when necessary.
- C. Source Quality Control
1. Material and fabrication procedures are subject to inspection and tests in the mill, shop, and field. These inspections and tests shall not relieve the responsibility for providing materials and fabrication procedures that are in compliance with the requirements.
- D. Pre-assemble components in the shop, to minimize field splicing and assembly of units at the project site. Disassemble units only to the extent necessary for shipping and handling. Clearly mark components, with permanent markings, for easy assembly at site of installation.
- E. Material Testing: The chemical compositions and appropriate mechanical properties shall be determined for all materials used, either by obtaining manufacturer's certificates of compliance or by laboratory testing at a facility which is acceptable to the Engineer.
- F. Weld Testing
1. Provide an AWS Certified Welding Inspector, employed by the fabricator, to perform specified fabrication and verification inspection of welding procedures and personnel, and to perform weld tests as specified herein. Submit qualifications of Welding Inspector to Caltrain for review and approval.
 2. Perform visual inspection of all welds in accordance with the AWS Code.
 3. Perform weld testing on a sample number of poles selected at random, comprising a minimum of 5% of the total number of poles.
 4. Equipment, procedures and personnel for weld testing, and test reports, shall conform to the requirements of AWS D1.1, Section 8, Inspection.
 5. Weld testing consists of:
 - a. Ultrasonic testing conforming to the requirements of AWS D1.1, Section 8;
 - b. Magnetic particle testing conforming to the requirements of ASTM E709.
 6. Test all poles selected for testing by the ultrasonic and magnetic particle methods.

7. Perform ultrasonic testing on complete penetration welds between the pole shaft and pole base, and on any circumferential welds in the pole shaft, for each pole being tested. Perform magnetic particle testing on all other welds including longitudinal seam welds, welds at handholes, etc.
 8. For each tested pole that is found to be unacceptable, weld testing shall be performed on a further sample of two (2) poles of each size, selected at random.
 9. Results of weld testing are deemed acceptable or unacceptable in accordance with AWS D1.1, Section 8.
 10. Repair unacceptable welds and retest.
- G. Test structural steel materials for base plates and pole shafts for impact toughness in accordance with the Charpy V-notch test as specified in ASTM A370. The minimum energy value shall be 15 ft.-lbs. at 40° F.

1.05 DELIVERY, STORAGE AND HANDLING

- A. During fabrication and delivery, steel products shall be handled and transported in a manner that will prevent damage occurring to the structural steel, galvanizing, and surface coatings.
- B. Store all poles and small part steelwork in accordance with the manufacturer's instructions, to ensure that all material is protected from damage or misuse prior to or during installation. Material shall not be stored in contact with the ground. It shall be stored in a manner and location that will not cause deterioration of the material.
- C. Repair or replace any damage to the poles and small part steelwork. All repairs and replacements shall be accomplished in accordance with the manufacturer's instructions. Any damage to the material and equipment shall be the Contractor's responsibility and all repairs shall be accomplished by the Contractor in accordance with the manufacturer's instructions, at no additional cost.
- D. Prepare poles and accessories and ship in a manner to prevent damage to the painted or weathering surfaces. Repair all damage to the exterior surface and coatings, in accordance with the manufacturer's instructions.
- E. Inspection of OCS poles and small parts steel components may be made on a regular basis prior to their erection. OCS poles and small parts steelwork shall not be stored in direct contact with the ground. All steel, galvanizing and painted coatings which become soiled or damaged by improper storage methods shall be repaired and returned to a like-new condition. The means and methods of security and protection for all stored items shall be approved by Caltrain.
- F. Poles shall be delivered to site at a rate and in a manner that will ensure uninterrupted work.
- G. When a pole, transported to the site, requires temporary storage prior to setting onto the foundation, it shall be stored above ground and in such a manner that it does not interfere with other Contractors' work or create a hazardous condition.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Provide poles that conform to AISC Specification, Code of Standard Practice for Steel Buildings and Bridges, and specification for Design, Fabrication and Erection of Structural Steel for Buildings.
 - 1. Conform to ASTM A143 to prevent embrittlement of the steel.
 - 2. Design steel and connections to withstand wind speed in compliance to ASCE 7-22, including overload factors for structure failure checking given in NESC/AREMA, in accordance with Caltrain Design Criteria.

- B. Retain for record purposes all certified test reports required to verify conformance to minimum yield strength. Such test reports may be the mill test reports for the as-received steel. When the as-received steel has lower yield strength than required, provide supportive test data, assuring that its method of cold forming will consistently increase the tensile properties of the steel to meet the specified minimum yield strength. Such supportive test data shall include tensile properties of the steel both before and after cold forming for specific heats and thickness.

- C. Furnish base plate assemblies with finished smooth surfaces. Provide neatly rounded corners, unless otherwise indicated on the Contract Drawings.

- D. Hot-dip galvanize all OCS poles and small steel parts, including their fittings and accessories after fabrication in accordance with ASTM A123 and A153, respectively. Galvanize each pole and part for its entire length in a single dipping operation. Successive dipping of poles will not be permitted.

- E. Pole shafts shall be straight with a permissible variation under no-load conditions not to exceed 1 inch measured from base to top.

- F. Demonstrate the deflection of each type of tubular steel and square tubular (HSS) pole furnished. The demonstration shall be in the form of a factory test performed at the place of manufacture. Perform non-destructive testing at a place and time agreed upon. Develop a test procedure for testing of the poles. Include as part of the test, method of application of loads, recording devices, calibration of devices, and any other pertinent information. Conduct tests on a rigid foundation that resists all translation and rotation about any axis.
 - a. Subject poles to the loads that will result in maximum pole deflection as defined in manufacturer's written literature. Apply the load 18 inches from the top of the pole and at right angles to its longitudinal axis. Upon removal of the load the pole at the point of load shall not show a permanent set exceeding 1/2 inch.
 - b. Conduct tests on no more than 5 percent of the poles in any lot of 20 or more with only one pole from any lot under 20. A lot is defined as the number of poles of any one size on a purchase order.

- c. If any pole fails the tests in any lot, an additional 5% of the poles from the same lot shall be tested. If any pole fails again, the entire lot will be rejected. As an option, each pole in the lot in question may be tested for acceptance.
- d. Provide at least 15 days notice prior to performing any tests.

2.02 STANDARD TAPERED TUBULAR POLES

- A. Provide tapered tubular, hot-dip galvanized steel poles, complete with base plates, hand holes, fittings, and accessories as indicated on the Contract Drawings. Conform to the requirements indicated herein and as specified in Article 2.1.
- B. Fabricate the poles from sheet steel of weld-able grade conforming to ASTM A595, Grade A, with the minimum yield strength of 55 ksi. Gauge of steel shall be as indicated on the Contract Drawings. Alternate designs may be submitted for approval.
- C. Pole shafts shall be fabricated of full-length sheets. Each section shall be fabricated from not more than 2 plies of sheet steel. Where 2 plies are used, longitudinal welded seams shall be directly opposite one another. When the sections are butt-welded together, the longitudinal welded seams on the adjacent section shall be placed to form continuous straight seams from base to top of the pole shaft.
- D. Where two-ply poles are used, the laminated pole thickness and moment of inertia shall be adjusted to compensate for the possible increase in deflections due to lamination effect.
- E. All welds shall be continuous.
- F. Supply poles with pole caps, cap mounting screws and all miscellaneous hardware required to complete the poles as shown on the Contract Drawings. Pole caps shall be galvanized pressed steel, fitted with three tamper-resistant stainless steel set screws. A manufacturer’s standard pole cap design such as pressed fit cap with set screw will be acceptable subject to Caltrain’s approval.
- G. All hardware and fastening devices including screws, nuts and bolts shall be stainless steel materials and tamper-resistant to prevent unauthorized tampering and/or disassembly of the completed pole installation.
- H. Fabricate base plates from structural steel conforming to ASTM A572, Grade 50. The minimum yield stress capacity of the base plate steel shall be not less than 90 percent of the yield stress capacity of the pole shaft steel.
- I. Welding electrodes and fluxes shall conform to the applicable requirements of AWS D1.1.
- J. Zinc used for hot-dip galvanizing shall conform to ASTM B6.
- K. Pole shafts, fittings, and accessories shall be fabricated to the tolerances conforming to the AISC Specifications, except as specified herein:

1. Pole tube base outside diameter to within 1/16 inch of the design diameter.
 2. Pole wall thickness to be within plus 10 percent and minus 5 percent of the design thickness.
 3. Pole taper to be a uniform rate of 0.14 in/ft, with a tolerance of +/- 0.02 inches, as indicated on the Contract Drawings.
 4. Pole length to be plus two inches and minus zero inches.
- L. Drill the inner ply of multiple-ply poles to provide drain relief holes for use during galvanizing. Arrange holes so that the strength of the pole is not reduced.
- M. Attach a manufacturer's pole identification sign to each pole immediately after fabrication including pole type, manufacturer, date of manufacture, and loading ratings.
- N. Identify pole type using one-half inch high die-stamped character on pole shaft and underside of base plate.

2.03 TUBULAR STEEL POLES HSS AND ROUND SECTIONS

- A. Use Tubular Steel Poles at locations indicated on the Contract Drawings. Conform to the requirements indicated herein and as specified in article 2.1.
- B. Fabricate HSS square and rectangular poles from ASTM A500, Grade C Steel, minimum yield stress 50 ksi. Fabricate round non-tapered from ASTM A500 Grade C Steel, minimum yield stress 46 ksi. Hot-Dip Galvanized per ASTM A123.
- C. Fabricate base plates from structural steel conforming to ASTM A572, Grade 50. The minimum yield stress capacity of the base plate steel shall be not less than 90 percent of the yield stress capacity of the pole shaft steel.
- D. Welding electrodes and fluxes shall conform to the applicable requirements of AWS D1.1.
- E. Zinc used for hot-dip galvanizing shall conform to ASTM B6.

2.04 WIDE FLANGE POLES

- A. Wide Flange Poles are to be utilized in open route conditions at locations indicated on the Contract Drawings. Conform to the requirements indicated herein and as specified in Article 2.01.
- B. Fabricate Wide Flange Poles from ASTM A992 Grade 50 ksi steel; Hot-Dip Galvanized per ASTM A123.
- C. Fabricate base plates from structural steel conforming to ASTM A572, Grade 50. The minimum yield stress capacity of the base plate steel shall be not less than 90 percent of the yield stress capacity of the pole shaft steel.

- D. Welding electrodes and fluxes shall conform to the applicable requirements of AWS D1.1.
- E. Zinc used for hot-dip galvanizing shall conform to ASTM B6.

PART 3 - EXECUTION

3.01 DELIVERY

- A. Deliver all small parts steel and OCS poles with integral base plates complete with associated fittings and accessories, properly packed and protected against damage and loss of parts.

3.02 INSTALLATION/ERECTION

- A. Erect structural steel in accordance with AISC Specification for structural steel erection or in accordance with manufacturer's recommended instructions.
- B. The pole rake to be determined such that the pole shafts appear to be vertical when the static OCS loads are applied at an ambient temperature of 80 deg F. Anchor base steel poles shall be raked by means of nuts and washers, with one nut and washer above, and with one nut and washer below, the pole base plate. After loading with wires and final tensioning, adjust down guys, where applicable, to ensure that poles are plumb. Refer to Caltrain Electrification Standard Design Criteria for maximum allowable live-load operating deflection of the pole and foundation structure within Section 3.15.2 OCS Pole and Foundation Requirements.
- C. Do not grout the space between the base plate and the foundation, unless otherwise indicated on the Contract Drawings. After the poles have been erected, install a second jam nut on top of the first nut above the baseplate so that the nuts cannot become loose or easily removed.
- D. All steel poles installed within station platforms must be electrically bonded only to the foundation ground cable and rod or counterpoise wire, as shown on the Contract Drawings.
- E. Set poles (unloaded) not earlier than seven days after foundations are installed. Do not load the OCS poles to the design requirements earlier than 28 days after foundations are installed, without approval by Caltrain.
- F. If pole bases are to be recessed below the platform or sidewalk level, the platform or sidewalk shall be restored with like materials to be flush with the adjacent surface. Do not restore platforms and sidewalks until after inspection of the pole installation, and after the pole has been loaded and OCS wires tensioned.
- G. Install the tubular poles so that the handhole (if any) is located on the side of the pole, away from the rail, street or the normal direction of approaching vehicular traffic. Face handholes on center poles located between tracks along the centerline of the trackway. Stainless steel hardware shall be used for handhole cover fasteners.

- H. Within 5 working days after installation, the poles shall be equipped with and display a temporary structure number. During the registration phase, a permanent structure number shall be installed in accordance with the Contract Drawings.
- I. Ground and bond all metal poles to the foundation as indicated on the Contract Drawings. Refer to Caltrain Standard Specifications Section 34 30 49.
- J. Pole caps shall be installed on all tubular poles prior to setting of the poles.
- K. Pole Installation Acceptance
 - 1. As part of the OCS acceptance procedures, measure and record the face-of-pole to centerline-of-track distances at rail level in accordance with the Acceptance Measurements form. Submit the Acceptance Measurements form for Caltrain review and approval. The pole-to-track distance is defined as the as-built horizontal clearance, centerline of track to closest pole face, for each track served.

END OF SECTION

SECTION 34 30 43

OCS SIGNAGE

PART 1 - GENERAL

1.01 DESCRIPTION

- A. This Section specifies requirements for the design, fabrication, supply, and installation of Overhead Contact System (OCS) pole identification signs and safety signs. These include signs for OCS poles, signal bridges, overhead bridges, and fences within electrified territories, as indicated on the Contract Drawings and detailed herein.
- B. OCS signage shall promote safety, comply with applicable electrical safety codes, and ensure clear identification for operational and maintenance purposes.

1.02 REFERENCE STANDARDS

- A. American National Standards Institute (ANSI):
 - 1. ANSI Z535 Series - Safety Signs and Colors
- B. American Society for Testing and Materials (ASTM):
 - 1. ASTM A36/A36M - Standard Specification for Carbon Structural Steel
 - 2. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
 - 3. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
- C. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. IEEE C2 - National Electrical Safety Code (NESC)
- D. Other
 - 1. American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual for Railway Engineering, Chapter 33 - Electrical Energy Utilization
 - 2. California Public Utilities Commission (CPUC) General Order 95, Rules for Overhead Line Construction.

1.03 REFERENCE DRAWINGS

Refer to Caltrain Standard Drawings for OCS Signage Details and Requirements.

1.04 SUBMITTALS

- A. Refer to Special Provisions Section 01 33 00, Submittal Procedures for review process.

- B. Product Data: Submit manufacturer's technical data, including material specifications, fabrication methods, installation instructions, and compliance certifications with referenced standards.
- C. Shop Drawings: Provide detailed drawings showing sign layouts, dimensions, materials, colors, text, graphics, mounting details, and locations. Include plans, elevations, sections, and anchorage details.
- D. Submit detailed lists of signs by group or type for Caltrain review and approval prior to commencing any work on a group or type of signs.
- E. Samples: Submit three (3) full-size samples of each sign type (pole identification and safety signs) for review prior to fabrication. Samples will not be returned.
- F. Sign Schedule: Submit a comprehensive list of all signs by type, location, text, and reference contract drawings.
- G. Qualifications: Submit evidence of manufacturer's experience in producing similar signage for rail electrification projects, including at least five (5) years of relevant work.
- H. Certifications: Provide certifications confirming compliance with ANSI Z535 for safety signs, NESC requirements, and material durability standards.

1.05 QUALITY ASSURANCE

- A. Perform all Work included in this Section in strict accordance with the requirements of Section 01 43 00, Quality Control and Assurance.
- B. Manufacturer Qualifications: Signage manufacturer shall have a minimum of five (5) years' experience in fabricating signage for electrified rail systems, demonstrating compliance with industry standards such as NESC and ANSI Z535.
- C. Mock-Up: Install a mock-up of one pole identification sign and one safety sign at a location designated by the Engineer for approval prior to full installation.

1.06 DELIVERY, STORAGE AND HANDLING

- A. Deliver, store and handle all signs and materials in such a manner to avoid damage.
- B. Store signs in a dry, secure area, elevated off the ground, and protected from weather, dirt, and physical damage.
- C. Handle signs carefully to avoid scratching, bending, or other impairments to finishes or reflective properties.
- D. Any sign damaged in shipping, handling, storage or installation shall be replaced by the Contractor at no additional cost to Caltrain.

1.07 WARRANTY

- A. Provide a warranty that all signs are suitable for outdoor use in harsh environmental conditions, including exposure to UV radiation, moisture, and temperature variations.
- B. Warrant against appreciable discoloration, cracking, blistering, peeling, or dimensional changes for a period of not less than 10 years from the date of Substantial Completion.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. General: All materials shall be new, durable, weather-resistant, and suitable for exterior rail environments. Signs shall be reflective to enhance visibility under low-light conditions.
- B. Pole Identification Signs: Provide signs conforming to the material type, size, and details shown on the Contract Drawings.
- C. Safety Signs: Fabricate from aluminum or fiberglass sheets, compliant with ASTM A36 or ASTM B209. Use colors and formats per ANSI Z535 (e.g., red for danger signs indicating high voltage hazards). Include standard warnings such as "DANGER - HIGH VOLTAGE" or as specified on Drawings.
- D. Fasteners and Hardware: Use stainless steel or galvanized steel hardware, compliant with ASTM A123, tamper-resistant where exposed.
- E. Adhesives: Very High Bond (VHB) adhesives or equivalent, recommended by the manufacturer for permanent bonding to pole surfaces.

2.02 FABRICATION

- A. Fabricate signs in a controlled environment to ensure quality and consistency.
- B. Letters and Numbers: Apply to the front face only (single-sided). Use specified typeface, with sizes as shown on Contract Drawings. Ensure raised or engraved elements for durability where applicable.
- C. Prepare all painted and adhering surfaces in accordance with the decal manufacturer's recommendations and made free from dirt, oil, and grease or other substances that prevent bonding.
- D. Pole Identification: Number poles in accordance with IDs on OCS Layout Plans. For center poles between tracks, apply identification on both sides facing traffic directions. Alternate pole identification sign installation locations may be proposed by the Contractor when blocked by OCS equipment, subject to Caltrain approval.
- E. The pole identification numbers shall be of the size shown on the Contract Drawings. Number in accordance with pole numbers or pole IDs shown on the OCS Layout Plans.
- F. Finishes: Apply protective coatings resistant to fading, corrosion, and abrasion.

PART 3 - EXECUTION

3.01 PREPARATION

- A. Contractor shall verify that installation surfaces (poles, bridges, fences, etc.) are clean, structurally sound, and ready for signage application before installation.
- B. Contractor shall clean surfaces to receive signs, removing dirt, grease, or foreign matter. Ensure surfaces are dry and at appropriate temperature for adhesive or fastener application.
- C. Report any discrepancies or unsuitable conditions to Caltrain before proceeding.

3.02 INSTALLATION / APPLICATION / ERECTION

- A. Install signs at locations and heights indicated on Contract Drawings, ensuring visibility from train operator cabs, maintenance access points and pedestrians where applicable.
- B. Pole Identification Signs: Affix to the side facing the normal direction of traffic. For center poles, apply on both traffic-facing sides. Use mechanical fasteners as appropriate for surface type. Adhesives shall not be allowed to affix signage to any surface.
- C. Safety Signs: Place at signal bridges, overhead bridges, and fences. Ensure signs are oriented for maximum visibility and comply with NESC clearance and placement requirements, as indicated on the Contract Drawings.
- D. Mounting: Use concealed fasteners where possible. For exposed fasteners, ensure they are tamper-resistant and match sign finish. Placement of signage on OCS wires shall not be allowed.
- E. Alignment: Install signs level, plumb, and securely attached to withstand wind loads and vibrations from rail operations.
- F. Install pole identification numbers to the side of the pole facing the normal direction of traffic (so it can be read by Train Operator). For the center poles located between the tracks, the identification numbers shall be affixed on both the sides of the traffic direction.

3.03 FIELD QUALITY CONTROL

- A. Contractor shall inspect installed signs for proper attachment, legibility, and compliance with Contract Drawings, Specifications and Manufacturer recommendations.
- B. Contractor shall repair or replace damaged signs at no additional cost to Caltrain.

3.04 CLEANING

- A. Contractor shall clean signs, remove any shipping protective films and surrounding areas from construction debris upon completion.

END OF SECTION

SECTION 34 30 46

PAINTING OCS POLES

PART 1 - GENERAL

1.01 DESCRIPTION

- A. This Section specifies requirements for the supply, surface preparation, and application of protective coatings to hot-dip galvanized OCS poles, structures, and small part steel attachments, as indicated on the Caltrain standard drawings, Contract Drawings, and in other Sections.
- B. Coordinate with the local municipal authority to paint and treat OCS poles in station areas and specified painted pole mitigation areas, as required by that authority, in accordance with this Section and Section 34 30 39, OCS Metal Poles. All poles shall be hot-dip galvanized prior to any finish treatments, regardless of the final coating system.
- C. Painted OCS poles and attachments as supplied from the manufacturer in a finished condition and/or items requiring factory or field painting shall conform to these Specifications.

1.02 QUALITY REQUIREMENTS

- A. Quality requirements shall be implemented in accordance with Section 01 45 00 — Quality Assurance and Quality Control, except as modified herein.
- B. Contractor shall coordinate with the galvanizer to confirm compatibility between the painting process and galvanizing process. Notify Caltrain of anticipated problems using specified coatings over substrates primed under other sections.
- C. Contractor shall ensure compatibility between all substrates, material finishes characteristics and primers used on the painted structure.

1.03 SUBMITTALS

- A. Refer to Special Provisions Section 01 33 00, Submittal Procedures for review process.
- B. Submit (3) color samples of each color to Caltrain. All samples shall identify locations where the paint will be applied on the Project.
- C. Submit (3) color samples of each color, paint data, application methods, and other submittals to each local municipal authority for OCS poles in station areas and in specified painted pole mitigation areas.
- D. Submit paint product data, primers, intermediate coats, and finish coats from the same manufacturer. List of materials cross-referenced to specific coating systems and applications, identified by catalog number and classification, if applicable. Material safety data sheets for primers, intermediate coats, finish coats, cleaning agents, and thinners.
- E. Submit paint shop application methods for all poles and steelwork, including

preparation methods, application procedures and special curing practices used.

- F. Submit paint manufacturer certification that selected paint is suitable for the intended application.
- G. Submit warranty documentation complying with Section 1.6 WARRANTY.
- H. Submit current SSPC certification for the painter.

1.04 DELIVERY, STORAGE AND HANDLING

- A. Store paint and tools per manufacturer's recommendations. Maintain containers clean, free of foreign materials. Protect from freezing. Keep area neat; remove waste daily. Store flammables per federal, state, and local requirements. Store and handle all painted equipment and material so as to not damage the finished surface.
- B. All unused paint and solvents shall be disposed of in an approved disposal site.
- C. Deliver materials in manufacturer's original, unopened packages with labels including product name, description, stock number, manufacture date, contents, thinning/application instructions, color, and handling precautions.
- D. Handle painted poles and structures to prevent damage to coatings. Deliver in finished condition; repair field touch-up per Specifications and manufacturer instructions.
- E. Paints intended for use in the field shall be stored in sealed containers that legibly show the designated name, formula, batch number, color, quantity, date of manufacture, manufacturer's number and directions including storage, special precautions, and warnings.

1.05 WARRANTY

- A. Guarantee the finish coating for a minimum of 10 years, with no major paint peeling, blistering, cracking or surface corrosion occurring within that period.

1.06 QUALIFICATIONS

- A. Applicator: Engage an experienced applicator with a minimum of (5) years of experience of proven record of completing similar painting system applications in material and extent for electrified rail applications, demonstrating successful in-service performance.
 - 1. Submit a list of completed projects, references including names, addresses, and contact information for engineers, architects, and owners, where identical products were applied.

1.07 REFERENCE STANDARDS

- A. American Society for Testing and Materials (ASTM):
 - 1. ASTM D6386, Standard Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Painting

PART 2 – PRODUCTS

2.01 MATERIALS:

- A. The term PAINT as used herein, includes powder coatings, emulsions, enamels, varnishes, paints and other protective sealers, whether used as a prime, intermediate or finish coat.
- B. Paint materials furnished shall be standard products of manufacturers regularly engaged in the protection of materials specified.
- C. The types of paint approved for use on OCS poles are as follows:
 - a. Primer paint to be a rust-inhibitive, high build epoxy coating, quick dry-recoatable, applied over a finished hot-dipped galvanized base component system having 1.5 mil thick (minimum) paint dry-film coat; equivalent to Sherwin Williams Industrial Recoatable Epoxy Prime (B67 Series).
 - b. Intermediate and Top Coating - To be acrylic polyurethane resin coating resistant to weather, abrasion and salt solutions, fast-dry product having a wide selection of available colors, semi-gloss, two-coat system, each coating to be 1.5 mil dry-film thickness, equivalent to Sherwin Williams Industrial Hi-Solids Polyurethane Resin (B65 Series).
- D. All paint products and coatings shall be selected, purchased, and used on the basis of a normal exterior exposure in an urban area with low humidity, intense sunlight, and temperatures ranging from -20 degrees to 120 degrees Fahrenheit. All paint products and coatings must be designed for this environment, having excellent resistance to corrosion, weathering, and demonstrating superior color retention.

2.02 FABRICATION

- A. OCS poles shall be hot-dipped galvanized in accordance with Section 34 30 39, OCS Metal Poles, before painting.

PART 3 - EXECUTION

3.01 TESTING AND INSPECTION

- A. All paint and its application shall be inspected for conformity with the manufacturer's recommendations and subject to Caltrain's approval.

3.02 APPLICATION

- A. Hot-dip galvanized OCS poles and accessories.
- B. OCS poles shall receive a surface treatment, prime coat, intermediate coat and finish factory paint coating as a finished treatment.
- C. Methods of surface cleaning and thicknesses of coat painting applied shall be as per manufacturer's recommendations.

- D. Painted surfaces shall have a minimum three-coat application. The coating shall consist of a primer, intermediate, and finish layer, each with a minimum dry 1.5 mil thickness. The total paint thickness shall not be less than 5 mils dry (excluding galvanizing) and shall be in accordance with the paint manufacturer's instructions.
- E. All paints shall be applied only to surfaces that are completely dry, clean, and free of surface moisture, dirt, dust, oil, mill scale, and detrimental coatings which will cause the paint to lose its bonding properties. The Contractor shall follow all requirements and suggestions provided by the paint manufacturer. Solvent clean all surfaces prior to the application of the prime coat. After 1 week, spot test the paint adhesion to the galvanizing to insure a permanent bond. Brush blast clean the entire galvanized surface if paint test proves unacceptable, in accordance with the paint manufacturer's recommendations.
- F. Items not to be painted, which are in contact with or adjacent to surfaces scheduled for painting, shall be removed or protected prior to surface preparation and painting operations. All masking and protective tapes shall be totally removed, without leaving residue, upon completion of the painting operations. Paint shall not be applied to any insulators, cable insulation, or other OCS components that are not specifically required to be painted.
- G. Prime Coat
1. Primers shall be capable of remaining in satisfactory condition for 6 months without the protection of a finish coat, for all field painting applications.
 2. Primers shall have sufficient penetrating and wetting properties to insure good coating regardless of the presence of light scale, or light rust on the surface to be painted.
- H. Intermediate Coat
1. The intermediate coat shall be of a composition similar to the final finish coat, as recommended by the paint manufacturer.
- I. Finish Coat
1. The finish coat shall be a coating suitable for protecting the surfaces to which it is applied. It shall completely hide the primer and intermediate coats and shall have no visible streaks, blisters, large runs, or obvious color or surface imperfections.
 2. Drying time to a tack free condition shall not be more than 24 hours.
- J. Paint shall be factory applied by dip, spray, or electro-coating except as herein specified. Field touch-up painting shall be by clean, dry brush or roller application, in accordance with paint manufacturer's instructions. At the time of application, all paint mixes shall show no signs of deterioration and be thoroughly mixed prior to applying. Powder coating over hot-dipped galvanizing shall be considered acceptable, pending demonstration of its in-service performance and application and shall be approved by the Engineer prior to manufacture.
- K. Paints of different manufacturers shall not be mixed together. Thinning is acceptable

prior to application where necessary to suit conditions of surface, temperature, weather and method of application with not more than one pint of approved thinner per gallon of paint or as per the paint manufacturer's instructions.

- L. Paint shall be applied so the final finished surfaces shall be free of visible runs, drops, blisters, brush marks, and variation of color, texture, and finish.
- M. Each coat shall be applied as a film of uniform thickness, not less than 1.5 mils dry. Special attention shall be given to insure that all surfaces including edges, corners, crevices, welds, voids, and base plates receive a film thickness equivalent to that of adjacent painted surfaces.
- N. Sufficient time shall elapse between successive coats to permit proper drying. The application of another coat shall not cause the lifting or loss of adhesion of the undercoat.

3.03 FIELD QUALITY CONTROL

- A. All painting activities shall be in accordance with these Specifications and are subject to inspection at any time.
- B. All paint which is unacceptable as applied, shall be removed or repaired in accordance with the paint manufacturer's instructions, and inspected for approval by Caltrain at the Contractor's expense.
- C. Repair all poles and steelwork which have paint damage due to mishandling, poor erection and/or storage practices. Accomplish all paint repairs in accordance with the paint manufacturer's instructions.
- D. All field paint applications, Caltrain shall inspect first finished completed item for each color scheme as a field sample, under illumination, matching expected final conditions. Field painting sample will be subject to Caltrain approval before Contractor may proceed to other locations.

END OF SECTION

SECTION 34 30 49

OCS GROUNDING AND BONDING

PART 1 - GENERAL

1.01 SUMMARY

- A. This Section includes requirements for furnishing, installing, and testing complete grounding and bonding systems for Overhead Contact System (OCS) structures, static wires, shunt wires, and related components as indicated on the Contract Drawings and Caltrain standard drawings. This encompasses, but is not limited to, OCS poles and structures, disconnect switch ground mats, and OCS surge arresters.
- B. The Contractor shall preserve the integrity of existing grounding and bonding systems throughout all phases of demolition and construction until the new system is fully operational. The Contractor shall prepare and submit detailed grounding and bonding plans for all proposed permanent configurations to Caltrain for review and approval.
- C. For grounding and bonding of all other system elements not included in this specification, see Section 26 05 26, Grounding and Bonding.

1.02 QUALITY ASSURANCE

- A. The following Codes, Regulations, Reference Standards and Specifications apply to the work included in this Section:
 - 1. Aluminum Association (AA)
 - 2. American Society for Testing and Materials (ASTM International)
 - 3. Institute of Electrical and Electronics Engineers (IEEE)
 - 4. National Fire Protection Association (NFPA)
 - 5. National Electric Safety Code (NESC)
 - 6. Underwriters Laboratories (UL)
- B. Source Quality Control: Each item UL-Listed.

1.03 SUBMITTALS

- A. Refer to Special Provisions Section 01 33 00, Submittal Procedures for review process.
- B. Submit the following to Caltrain for review and approval:
 - 1. Bonding Plans: Detailed plans for all temporary and permanent grounding and bonding configurations.
 - 2. Shop Drawings:

- a. Locations of ground rods, connectors, cables, and details of connections and terminations.
- C. Certification: Certified test reports verifying that ground resistance, when grounding and bonding is installed to the ground rods, does not exceed the values specified in Article 3.2.
- D. Product Data: For each specified product, including ground rods, conductors, connectors, exothermic welding systems, and associated components.
- E. Test Procedures: Detailed procedures and equipment for testing resistances and electrical continuity.
- F. Test Reports: Certified reports verifying ground resistance values, including results for each location in table form. Reports shall confirm that ground resistance does not exceed specified values.
- G. As-Built Drawings: Drawings of all grounding systems as installed, in accordance with the Specifications.

1.04 REFERENCES

- A. Aluminum Association (AA)
 - 1. 90, Aluminum Standards and Data.
- B. American Society for Testing and Materials (ASTM)
 - 1. A666, Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
 - 2. B8, Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
 - 3. B187, Specification for Copper, Bus Bar, Rods and Shapes and General Purpose Rod, Bar, and Shapes.
 - 4. B231, Specification for Concentric-Lay-Stranded Aluminum 1350 Conductors.
- C. Institute of Electrical and Electronics Engineers (IEEE)
 - 1. 81, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.
- D. National Fire Protection Association (NFPA)
 - 1. National Electric Code (NEC)
- E. Underwriters Laboratories (UL)
 - 1. 467, Safety Grounding and Bonding Equipment.

F. Caltrain Standard Grounding and Bonding Drawings

PART 2 - PRODUCTS

2.01 MATERIALS

- A. General: Grounding and bonding equipment shall comply with UL 467 and be listed and labeled for the intended application.
- B. Ground Rods: Copper clad steel or other material as shown on the drawings. Unless otherwise indicated minimum dimensions shall be $\frac{3}{4}$ inch diameter by 10 feet long. Sectional or multiple ground rods shall be used where required to attain the ground resistances shown on the drawings and specified herein.
- C. Grounding Conductor:
 - 1. Grounding Conductors
 - a. Bare, covered aluminum, copper-clad steel, or copper conductor as shown on the Contract Drawings.
 - b. Sizes: In accordance with NEC Table 250.102(C)(1).
- D. Terminal Lugs:
 - 1. For 4/0 AWG and Smaller Conductors: Copper and aluminum compression terminal lugs.
 - 2. For 250 MCM and Larger: Long barrel, copper, double-compression terminal lugs.
- E. Ground Connectors:
 - 1. O-Z Gedney, Type KG or equal.
 - 2. Copper alloy body and silicon bronze bolt, nut and washer with interlocking clamp.
 - 3. Exothermic Welds: Size and type per manufacturer's recommendations.
- F. Jumpers:
 - 1. Aluminum or copper braided or leaf-type flexible jumper, size as shown on Caltrain's standard and contract Drawings.

PART 3 - EXECUTION

3.01 GROUNDING

- A. Ground Connections to OCS Poles:
 - 1. Install a ground rod in each OCS foundation with size and location in accordance with the standard drawings and grounding and bonding design.

2. Install a bonding conductor between the ground rod, anchor bolts, and rebar cage. For configuration and number of connections see the standard drawings.
3. After pole installation, provide a ground wire connection between the foundation ground rod and the pole as indicated on the standard drawings.
4. Alternate grounding methods may be implemented in high copper theft areas by using materials and designs that discourage or prevent theft, such as copper-clad steel cables, composite cables, galvanized steel straps, or concealment strategies. Contractors working in such environments may propose specific solutions for review and approval by Caltrain.

3.02 FIELD QUALITY CONTROL

- A. Test ground resistance of each ground grid after installation and each subsystem independently or when connected to the system ground, as appropriate, in accordance with the test plan and specification Section 34 30 86, OCS Testing.
- B. Ground resistance shall not exceed the following:
 1. Pole Mounted Disconnect Switch Ground Mat: Five (5) ohms
 2. OCS Surge Arresters: Five (5) ohms
 3. OCS Poles: Twenty-five (25) ohms
 4. Shunt Wire Five: (5) ohms
- C. Record ground resistance test results at each location, in table form, for review by Caltrain.
- D. In the presence of Caltrain and prior to backfilling ground rod hole, test the grounding installation to demonstrate that the total ground resistance does not exceed the required values.
- E. To meet maximum allowable ground resistance requirements, install additional ground rods or counterpoise as necessary.
- F. If any of the test results exceed the maximum resistance, install additional ground rods and retest.
- G. Test metallic conduit and raceways, equipment enclosures, metallic cable troughs, fences, hand railings, metallic structures, and light standards for continuity to subsystem grounding.
- H. Prepare and submit certifications as specified by Caltrain.

END OF SECTION

SECTION 34 30 51

OCS SUPPORT AND REGISTRATION ASSEMBLIES

PART 1 - GENERAL

1.01 DESCRIPTION

- A. This Section specifies the design, manufacture, supply, and installation of the following types of OCS support and registration assemblies for the Overhead Contact System, as shown on the Contract Drawings and specified herein.
1. Pull-Off Single-Track Cantilevers
 2. Push-Off Single-Track Cantilevers
 3. Non-Riding and Support-Only Single-Track Cantilevers
 4. Twin Cantilevers
 5. Two-Track Cantilevers
 6. Existing Multi-Track Headspan Support and Registration Assemblies (Headspans are not allowed in future projects without Caltrain approval.)
 7. Existing Multi-Track Cross-Span Support and Registration Assemblies
 8. Wire Pull-Off and Backbone Registration Assemblies
 9. Aerial Head Guy Supports
 10. Overhead Bridge Support Assemblies
 11. Down Guy Assemblies
 12. Contact Wire Bridges
 13. Section Insulators
- B. Furnish and install cantilever assemblies for supporting the overhead wires. The cantilevers shall be installed as shown on the Contract Drawings and in accordance with the manufacturer's instructions, with field measurements taken immediately prior to fabrication to determine as-built dimensions from the centerline of track to the face of the pole at contact wire or messenger wire height. Due allowance shall be made during fabrication for dead load deflection of the pole and wire staggers.
- C. Furnish and install messenger, contact, cross-span, aerial head guy, backbone, pull-offs, bridge support, and registration assemblies as shown on the Contract Drawings. All assemblies shall be of a proven design that has been successfully used on other highspeed overhead electrified rail systems for a minimum of 5 years, demonstrating acceptable performance history and in-service life.

1.02 REFERENCES

- A. Codes and Standards: Pertinent provisions of the following listed standards shall apply, except as they may be modified herein, and are hereby made a part of this Section.
 - 1. American Society for Testing and Materials (ASTM):
 - a. A572, Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
 - b. A53, Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
 - c. A47M, Specification for Ferritic Malleable Iron Castings.
 - d. A123, Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - e. A153, Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 - f. A484, Specification for General Requirements for Stainless Steel Bars, Billets, and Forgings.
 - g. A530, Specification for General Requirements for Specialized Carbon and Alloy Steel Pipe.
 - h. A992, Specification for Structural Steel Shapes.
 - i. B150M, Specification for Aluminum Bronze Rod, Bar, and Shapes.
 - 2. European Committee for Electrotechnical Standardization (CENELEC) Standards

1.03 QUALITY CONTROL

- A. Perform the Work included in this Section in strict accordance with Section 01 43 00, Quality Control and Assurance.

1.04 SUBMITTALS

- A. Refer to Special Provisions Section 01 33 00, Submittal Procedures for review process.
- B. Certification: Furnish a certification to Caltrain verifying that all materials included in the OCS support assemblies have been designed, manufactured, inspected, and tested in accordance with the Contract Documents, referenced standards, and these Specifications. Additionally, submit certification to Caltrain for record purposes, including calculations for the design of each assembly to demonstrate adequate load capacity in the configuration as used.
- C. Test Reports: Furnish copies of reports of all factory tests required by the Contract Documents, referenced standards, and these Specifications to Caltrain.

- D. Manufacturer's Data: Furnish complete manufacturer's data and shop drawings to Caltrain.
- E. Shop Drawings: Furnish a complete set of assembly and component drawings to Caltrain for review and approval showing dimensions, fit, weights, breaking strengths, bill of material, catalog cuts, manufacturer country of origin, and related product data for all OCS supporting devices proposed for use on the project.
- F. Calculations: Submit, along with the Shop Drawings, a complete package of design calculations showing that the strength of hardware selection is suitable for the application, to Caltrain for review and approval. All used equations within the calculation will be shown in full for review by Caltrain.
- G. Operation and maintenance data for all components addressed in this Section shall be provided in accordance with Section 34 30 93, OCS Manuals and Training.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. All OCS support and registration assemblies, components and materials shall be protected against damage during handling and shipping, storage and installation.
- B. Store material to permit easy access for inspection and identification. Protect steel members and packaged materials from corrosion and deterioration.
- C. All packaged components and/or assemblies shall have a strong waterproof tag securely fastened to the package showing the assembly or component name, number, or identification code.

PART 2 - PRODUCTS

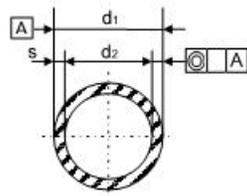
2.01 MATERIALS

- A. All materials used in the components of the OCS support and registration assemblies shall be of sufficient strength and durability to withstand the applicable worst-case loads with the addition of a factor of safety of 2.5 relative to operating conditions.
- B. The material shall be strong, light in weight and reliable to ensure a 40-year minimum life period.
- C. The OCS support and registration assemblies shall be as per Caltrain standard OCS basic design range or equivalent. Any variation shall be approved by Caltrain and OCS proposed shall be of a proven and tested design, which shall have successfully been used on other high-speed overhead electrified rail systems for a minimum of 5 years.
- D. The Contractor shall furnish all labor, tools, equipment, apparatus and facilities as required to perform all fabrication and installation work as required.
- E. All beam clamps, plates, anchor bolts, and other devices proposed for use as overhead bridge attachments shall be selected as appropriate for each bridge. Attachments to bridges shall only be used at structure locations specified on the Contract Drawings. Field drilling of bridge girder webs will not be permitted unless expressly permitted by Caltrain, with written permission provided prior to any related work.

2.02 METAL CHARACTERISTICS

- A. Metal parts shall be manufactured in accordance with applicable DIN, EN standards or ASTM Standards.
- B. For metal parts conforming to ASTM Standards, requirements shall be as follows:
 - 1. Malleable Iron: Fittings or components made of malleable iron shall be grade 32510 or better, and shall conform to ASTM A47M. All components and fittings shall be galvanized in accordance with ASTM A153M.
 - 2. Structural Steel: Material for structural steel (not including cantilever pipe) shall comply with ASTM A572 Grade 50 or ASTM A992 Grade 50. Galvanize material in accordance with ASTM A153.
 - 3. Stainless Steel: Stainless Steel material shall conform to ASTM A484.
 - 4. Aluminum components shall conform to ASTM B150.
 - 5. Structural steel for overhead bridge attachments and miscellaneous devices shall conform to ASTM A572 Grade 50 or ASTM A992 Grade 50 generally conforming to the structure receiving the attachment. Non-weathering steel applications shall be provided with a paint system, subject to Caltrain’s approval.
- C. Cantilever Pipe: Material for all cantilever pipe or tubes shall be aluminum in accordance with the following:
 - 1. Standards
 - a. DIN EN 754 – Part 1 and 2 wrought aluminum and aluminum alloy tubes.
 - b. DIN EN 755 P7 - Round tubes of wrought aluminum and aluminum alloys.
 - c. EN 755-2 - Extruded rods/bars, tubes and profiles.
 - d. DIN ISO 228-1 - Pipe threads where pressure-tight joints are not made on the threads.
 - 2. Material
 - a. EN AW-ALSi1MgMn according to DIN EN 755-2.
 - b. T6 according to DIN EN 515.
 - 3. Tolerances
 - a. DIN EN 755-7, except the assigned values (*).
 - b. Table 1: Tolerances for tubes.

Tube $d_1 \times s$	Tolerance			A mm^2	J cm^4	W cm^3	Weight $kg\ m$	Application
	Δd mm	Δd_1 mm	$\Delta s\ %$					
26 x 3.5	+0.30 -0.30	+0,70 -0,70	±8%	247.40	1.603	1.233	0.668	Stay, steady arm and top tube
42 x 4	+0.35 -0.35	+0.90 -0.90	±8%	477.52	8.715	4.150	1.289	Registration, top and weight guide tube
55 x 6	+0.40 -0.40	+0.60* -0.60*	±8%	923.63	28.136	10.231	2.494	Strut, top and registration tube
70 x 6	+0.40 -0.40	+0.70* -0.70*	±8%	1206.37	62.309	17.803	3.257	Strut tube
80 x 6	+0.60 -0.60	+1.40 -1.40	±8%	1394.87	96.106	24.027	3.766	Strut tube
100 x 10	+0.60 -0.60	+1.40 -1.40	±8%	2827.43	289.812	57.962	7.634	Drop tube
120 x 12	+0.90 -0.90	+1.40 -1.40	±8%	4071.50	600.954	100.159	10.993	Drop tube



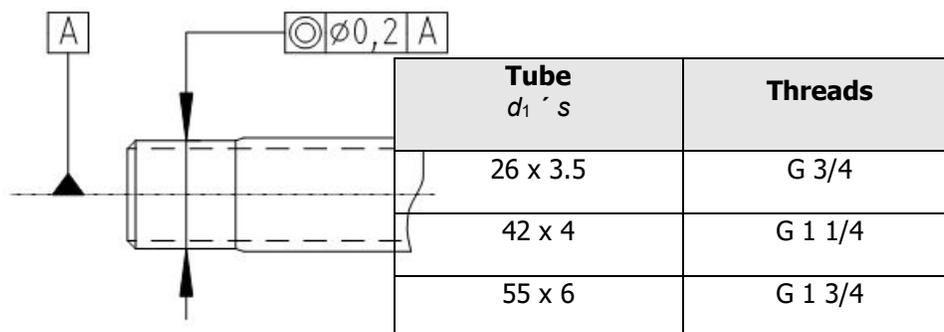
$\Delta \bar{d}$ = tolerance of deviation mean diameter

Δd_1 = tolerance of deviation diameter

Δs = non uniformity of wall thickness

$\Delta \odot$ = coaxiality based on level A

- Table 2: Coaxial tolerances for threads.



- D. All cotter pins, roll pins, spring clips, and hitch pins shall be stainless steel.

PART 3 - EXECUTION

3.01 INSTALLATION REQUIREMENTS

- A. Installation of OCS supporting devices shall be in accordance with Section 34 30 85, OCS Installation.

END OF SECTION

SECTION 34 30 53

GALVANIZED STEEL WIRE AND WIRE ROPE

PART 1 - GENERAL

1.01 DESCRIPTION

- A. This Section includes specifications for the manufacture, supply, fabrication, and installation of all grades of galvanized steel wire, wire-strand terminations, wire assemblies, and wire rope for use with down guys, aerial head guys, pull-offs, backbone wire and various other usages for the Overhead Contact System (OCS) as shown on the Contract Documents and specified herein.

1.02 REFERENCED STANDARDS

- A. Pertinent provisions of the following listed standards shall apply to the work of this Section, except as they may be modified herein, and are hereby made a part of this specification to the extent required:
 - 1. American Society for Testing and Materials (ASTM):
 - a. A475, Specification for Metallic-Coated Steel Wire Strand.

1.03 QUALITY ASSURANCE

- A. Perform work in this Section in strict accordance with the requirements of Section 01 43 00, Quality Control and Assurance.

1.04 SUBMITTALS

- A. Refer to Special Provisions Section 01 33 00, Submittal Procedures for review process.
- B. Submit manufacturer's data sheets and related reports for each type of wire, wire rope and synthetic strand rope to be used shall contain the physical and mechanical properties of all components described in this Section. The conformance of components with the requirements of the Contract Documents shall be in the form of a manufacturer's certification. Include the following as a minimum:
 - 1. Size
 - 2. Type
 - 3. Material
 - 4. Number of and diameter of individual wires
 - 5. Overall diameter
 - 6. Cross-section area
 - 7. Weight per foot

8. Rated breaking strength
 9. Zinc coating weight
 10. Project use and product application data
 11. Modulus of Elasticity
 12. Coefficient of Thermal Expansion
- C. Provide certification that the galvanized steel wire, wire rope and synthetic strand rope have been designed, fabricated, rated and tested in compliance with the applicable provisions of the standards referenced in these Specifications.

PART 2 - PRODUCTS

2.01 DESCRIPTION

- A. Manufacture zinc-coated stranded wire and tested in accordance with ASTM A475.
- B. Physical properties of the zinc-coated stranded wire to conform to the description in Table 1 of ASTM A475.
- C. The material used for stranded steel wire and wire components to conform to ASTM A475.
- D. The weight of coating for zinc-coated steel wire shall not be less than that specified in Table 4, under Class C of ASTM A475.

PART 3 - EXECUTION

3.01 DELIVERY AND MARKING

- A. Protect against damage during handling and shipping. Each reel shall have a strong, weatherproof tag securely fastened to it showing the physical and mechanical properties, as well as the steel type designation, ASTM designation and the name and mark of the Manufacturer, the total length and weight of the wire, wire rope or strand rope on each reel or bundle.

3.02 GENERAL INSTALLATION REQUIREMENTS

- A. Galvanized steel wire, wire rope and synthetic strand rope shall be cut and installed using tools and methods specified by the Manufacturer.
- B. Splicing of the galvanized steel wire, wire rope and synthetic strand rope will not be permitted under any circumstance.
- C. For additional installation requirements see Section 34 30 85, OCS Installation.

END OF SECTION

SECTION 34 30 56

STAINLESS STEEL WIRE ROPE, STRAND AND ROD

PART 1 - GENERAL

1.01 DESCRIPTION

- A. This Section includes specifications for the design, supply, fabrication and installation of stainless steel wire rope, stainless steel wire strand and stainless steel rod for the Overhead Contact System (OCS) as shown on the Contract Drawings.
- B. The stainless steel wire rope, strand and rod shall be suitable for the uses as shown, fully acceptable for use on a 110 mph Overhead Contact System, providing a usable and maintainable wire arrangement.

1.02 REFERENCE STANDARDS

- A. The following standards shall apply and are made a part of this Specification:
 - 1. American Society for Testing and Materials (ASTM):
 - a. A276, Specification for Stainless Steel Bars and Shapes.
 - b. A368, Specification for Stainless Steel Wire Strand.
 - c. A492, Specification for Stainless Steel Rope Wire.
 - d. A555, Specification for General Requirements for Stainless Steel Wire and Wire Rods.
 - e. A580, Specification for Stainless Steel Wire.

1.03 QUALITY ASSURANCE

- A. Perform the work included in this Section in strict accordance with Section 01 43 00, Quality Control and Assurance.

1.04 SUBMITTALS

- A. Refer to Special Provisions Section 01 33 00, Submittal Procedures for review process.
- B. Certification: Furnish certifications verifying that the stainless steel wire rope, strand and rod have been designed, manufactured, inspected and tested in accordance with the referenced standards and these Specifications.
- C. Test Reports: Furnish copies of reports of all factory test procedures and results as required by these Specifications and referenced standards.
- D. Product Data: Furnish complete manufacturer's dimensional, mechanical, material, and physical data for stainless steel wire rope, strand, and rod.

- E. Project Use: Furnish complete size and application data for all types of wire rope, strand and rod used for the OCS configurations as per Caltrain standard OCS basic design range.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Ship wire rope and strand on reels suitable for the weight carried and acceptable transport methods to the manufacturer.
- B. The rod shall be shipped on reels suitable for the weight carried or in straight lengths, securely bundled. Straighten rods shipped on reels prior to use.
- C. Protect all material against damage during handling, shipping and storage. On each reel or bundle, provide a strong, weatherproof tag securely fastened showing the physical and mechanical properties as well as type designation, ASTM designation and the name and mark of the manufacturer, the total length and weight of the wire rope, strand or rod on each reel or bundle.
- D. Handle and store products according to manufacturer's recommendations. Leave products wrapped or otherwise protected and located under clean and dry storage conditions when necessary, until required for installation.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. General:
 - 1. Austenitic grade stainless steel
 - 2. High corrosion resistance
 - 3. Compatible with component items
 - 4. Designed to carry maximum working loads with a factor of safety of 2.5 minimum based on yield stress.
- B. Stainless Steel Wire Rope:
 - 1. Extra flexible
 - 2. Non-rotating for use as indicated on the Contract Drawings.
 - 3. Manufactured and tested in conformance with requirements of ASTM A368, A492, A555 and A580.
- C. Stainless Steel Wire Strand:
 - 1. Manufactured and tested in conformance with requirements of ASTM A368, A555 and A580.
- D. Stainless Steel Rod:
 - 1. Round

2. Manufactured and tested in conformance with requirements of ASTM A276.

2.02 FABRICATION

- A. All materials and assemblies shall be suitable for field adjustment.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Installation of wire rope and strand shall be in accordance with the Caltrain Standard Drawings.
- B. Refer to Section 34 30 85, OCS Installation.

END OF SECTION

SECTION 34 30 61

OCS INSULATORS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. This Section includes specifications for the supply, testing and installation of insulators for the Overhead Contact System (OCS), as shown on the Caltrain standard drawings and specified herein. This work shall include, but not limited to the following:
1. Cantilever Pipe Insulators
 2. Messenger Wire In-Span, MPA and Termination Insulators
 3. Contact Wire In-Span and Termination Insulators
 4. Feeder Line-Post and Termination Insulators
 5. Static Wire OCS Pole Termination at Passenger Platforms
 6. Overhead Bridge Support Insulators
 7. Headspan, Cross Span, Pull-Off and Aerial Head Guy Wire Insulators
 8. Other Miscellaneous Insulators (as shown on Contract Drawings)
- B. All OCS insulators shall conform to the features, performance requirements, and standards stated herein and as shown on the standard drawings.
- C. All contact wire "riding-type" insulators for use on Section Insulator assemblies are not part of this Section but are specified separately in Section 34 30 63, Section Insulators.
- D. Supply and install all applicable insulators for the overhead wires and cables associated with the 2 x 25 kV AC Overhead Contact System, in accordance with the requirements specified and as shown on the standard drawings.

1.02 REFERENCES

- A. Codes and Standards: Pertinent provisions of the following listed standards shall apply:
1. American National Standard Institute (ANSI):
 - a. C2, National Electrical Safety Code.
 - b. C29.1, Test Methods for Electrical Power Insulators.
 2. American Society for Testing and Materials (ASTM):

- a. A153, Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 - b. D149, Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.
 - c. D229, Standard Test Method for Rigid Sheet and Plate Materials Used for Electrical Insulation.
 - d. D256, Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics.
 - e. D570, Standard Test Method for Water Absorption of Plastics.
 - f. D624, Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers.
 - g. D635, Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position.
 - h. D638, Standard Test Method for Tensile Properties of Plastics.
 - i. D695, Standard Test Method for Compression Properties of Rigid Plastics.
 - j. D696, Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics Between -30°C and 30°C with a Vitreous Silica Dilatometer.
 - k. D732, Standard Test Method for Shear Strength of Plastics by Punch Tool.
 - l. D790, Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
 - m. D1149, Standard Test Methods for Rubber Deterioration - Cracking in an Ozone Controlled Environment.
 - n. D2303, Standard Test Methods for Liquid - Contaminant, Inclined-Plane Tracking and Erosion of Insulating Materials.
 - o. G21, Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
3. American National Standards Institute (ANSI):
 - a. C29, High-Voltage Insulators.
 - b. C135.20, Zinc-Coated Ferrous Insulator Clevises.
 4. EN Standards:

- a. 50124-1, Railway applications - Insulation coordination - Basic requirements - Clearances and creepage distances for all electrical and electronic equipment.
- 5. IEC Standards:
 - a. 61109, Insulators for overhead lines - Composite suspension and tension insulators for AC systems with a nominal voltage greater than 1000 V - Definitions, test methods and acceptance criteria.
 - b. 61952, Insulators for overhead lines - Composite line post insulators for AC systems with a nominal voltage greater than 1000 V.
- B. Insulators may be manufactured in accordance with the applicable IEC and EN standards in lieu of the ANSI/ASTM standards indicated above.
- C. Factory Quality Control: Factory tests shall be made as required by these Specifications and the referenced standards. Test reports shall be submitted as detailed herein.

1.03 QUALITY CONTROL

- A. The Contractor shall perform the Work included in this Section in strict accordance with Section 01 43 00, Quality Control and Assurance.

1.04 SUBMITTALS

- A. Refer to Special Provisions Section 01 33 00, Submittal Procedures for review process.
- B. Submit shop drawings to Caltrain for review and approval prior to insulator manufacture, showing details and dimensions of the insulating and metallic parts, describing the material composing the various parts, together with technical, mechanical and electrical characteristics and performance data.
- C. Prepare and submit to Caltrain an insulator device (assembly) loading data to indicate the maximum design loading condition (axial and transverse) that each type of insulator can safely withstand.
- D. Submit as per test plan to Caltrain for approval, details of the factory tests proposed for each insulator and the procedures and forms to be used during the factory tests and inspection.
- E. Certification:
 - 1. Provide certificates of compliance to Caltrain for the following:
 - a. Steel analysis
 - b. Hot dip galvanizing
 - c. Adhesive materials

- d. Insulator materials
 - e. In-service performance record of proposed insulators
 - f. Certified Quality Control Procedures used in the manufacturing process
2. Submit data to Caltrain for approval prior to insulator installation:
- a. A complete set of assembly, component, and detail drawings showing dimensions, weights and the form, fit and function of all items.
 - b. Storage, handling and installation instructions.
 - c. Details of any specifications for materials included in the insulator assembly which are not covered in the Contract Documents.
- F. Inform Caltrain at least two (2) weeks in advance of the date on which insulators will be ready for inspection and tests.
- G. Submit one sample to Caltrain of each type of insulator to be used on the project.
- H. The insulators shall be maintenance free. If the manufacturer/supplier recommends specific maintenance procedures and service data, they shall be submitted to Caltrain prior to the manufacture and supply of all insulators.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Ensure that all materials furnished are suitably packaged and protected against damage during delivery and transportation.
- B. Store all products in accordance with the manufacturer's instructions, to ensure that all material is protected from damage and exposure.
- C. Handle the insulators in accordance with the manufacturer's instructions, so as to ensure that the products are not damaged or misused prior to or during installation.
- D. Repair or replacement any damaged insulators in accordance with the manufacturer's instructions.
- E. Contractor shall clean all insulators with an approved product recommended by the manufacturer just before final installation in the field.

1.06 WARRANTY

- A. The insulators shall have a minimum in-service life expectancy of 40 years under normal high speed rail operating conditions.
- B. The insulators shall be unconditionally guaranteed in writing by the manufacturer and/or supplier to be free from operational and manufacturing defects for a period of not less than 5 years.

PART 2 - PRODUCTS

2.01 DESCRIPTION

- A. The insulators covered by this Specification are for use in the following applications, and are to be non-ceramic:
 - 1. OCS Insulators
 - a. Cantilever Pipe Insulators - for the configuration and insulation of the OCS assembly pipe/tube frames, mounted to the poles. These shall be manufactured from glass fiber reinforced resin with suitable weathersheds.
 - b. Messenger Wire In-Span and Termination Insulators - For the vertical and horizontal support, cut-in (tension) and termination (strain) of the main messenger wire which supports the OCS hangers and contact wire. These shall be manufactured from glass fiber reinforced resin with suitable weathersheds.
 - c. Contact Wire In-Span and Termination Insulators - For the horizontal cut-in (tension) and termination (strain) of the grooved contact wire for the Overhead Contact System. These shall be manufactured from glass fiber reinforced resin with suitable weathersheds.
 - d. Contact Wire Non-Riding Insulators - For the horizontal insulation of the grooved contact wire as a cut-in (tension) member used on short span overlaps where uplift may cause the pantograph to hit a normal weathershed insulator. These shall be manufactured from glass fiber reinforced resin without weathersheds.
 - e. Feeder Termination and Line-Post Insulators - For the 25 kV AC system feeder wires supported on the OCS structures. These shall be manufactured from glass fiber reinforced resin with suitable weathersheds.
 - f. Headspan, Cross Span, Pull-Offs and Aerial Head Guy Termination Insulators - For the horizontal insulation of the headspan, cross span, pull-off wire and aerial head guy termination wires. These shall be manufactured from glass fiber reinforced with suitable weathersheds.

2.02 NON-CERAMIC INSULATOR MATERIALS

- A. The non-ceramic insulators shall be of varying types, dependent upon usage. Non-ceramic insulators with cast composite bodies may incorporate performance-proven metal threaded inserts. Other non-ceramic insulators will be a unit consisting of a non-metallic rod, weathersheds as required, and end fittings. The rod shall be made of glass fiber or reinforced polymer (like PTFE), with its fibers running longitudinally through the rod length. The rod may be attached to the end fittings or hardware by a compression sleeve, wedge or adhesive. If adhesive is used, the adhesive shall encapsulate the rod in the end-fitting cavity and shall form a compressive wedge

upon loading. Weathersheds shall, for the expected life of the insulators, protect the rod from the elements and ensure the necessary leakage distance.

- B. The non-ceramic insulators shall be constructed so as to be a lightweight, compact unit with high-impact strength. Weathersheds shall be "self-cleaning" and weather resistant to reduce the possibility of ice-bridging between sheds. They shall be of a material that is vandal resistant insofar as being shatter- proof, thereby reducing vandalism damage.
- C. The insulator's metal parts shall be made of malleable iron, ductile iron, or forged steel and be galvanized in accordance with ASTM A153 or applicable European Standard. Metal parts shall be galvanized prior to assembly to the fiberglass rod or composite material insulator body.
- D. All insulator types used shall be capable of withstanding service in an environment which includes exposure to ultraviolet radiation, moisture, surface discharges, ozone, temperature extremes, diesel engine exhaust fumes, and a diversity of contaminants such as industrial pollutants.
- E. The insulators shall be designed to be capable of maintaining the integrity of the weathershed material at all component interfaces. The interface between fiberglass rod and weathershed, or composite material body and weathershed shall, for the life of the insulator, remain void-free and dry. Color shall be manufacturer's standard.
- F. The resin-bonded glass fiber rods shall be sound and free from any defects or blemishes which may affect the life and performance of the insulator. It shall be of uniform quality throughout its length.
- G. All non-ceramic material shall have a smooth, void-free finish. All adhesive coatings shall be sealed to the fittings to protect them against the ingress of moisture.
- H. The design shall be such that stress due to temperature variation, and mechanical extension/contraction in any part of the insulator under load and normal handling, shall not lead to deterioration. The materials used shall not cause degradation by chemical interactions.
- I. The end fittings attached to the fiberglass rod type insulator shall ensure exact alignment with the rod and correct assembly in respect to each other to avoid torsional stress when the insulator is installed.
- J. The insulators shall be so designed that no sparking or arcing shall occur on or across the surface of the insulator when energized at the maximum design voltage under clean and dry conditions.

2.03 SPECIFIC REQUIREMENTS

- A. All insulators shall include the fittings and connections for attachment to the pipe, pole or steelwork, as shown.
- B. The insulator shall be suitable for both horizontal and vertical mounting and installation, unless otherwise specified.

- C. The skirt or weathershed of all insulators shall be of sufficient diameter to meet the electrical requirements.
- D. The insulators shall be formed to fit the specified conductors as shown on the Contract Drawings.

2.04 TECHNICAL CHARACTERISTICS AND DIMENSIONS

- A. Technical characteristics of the insulators shall be as shown and indicated herein.
- B. Insulator Characteristics:

1.	Nominal Voltage:	25kV AC
2.	Insulation class:	46kV
3.	Basic Insulation Level:	250kV AC, RMS
4.	Creepage Distance:	45" (Min)
5.	Dry Flashover:	160kV
6.	Wet Flashover:	125kV

2.05 MARKING

- A. Each insulator shall bear the manufacturer's name or trademark, batch and year of manufacture, clearly and permanently imprinted without leaving any irregularity that would affect the electrical and mechanical performance of the insulator.

2.06 PRODUCTION TESTS AND FABRICATION

- A. The following tests shall be performed in accordance with ANSI C29.1 and Test Plan:
 - 1. Visual and Dimension Test:
 - a. The entire surface shall be smooth and free from defects.
 - b. If adhesives are used, the insulator shall be inspected to see that the filet of adhesive provides a complete seal between the coating and end fitting.
 - c. The insulator shall be inspected to verify that both end fittings are in line after being assembled on the rod.
 - d. The insulator shall be in accordance with shop drawings for which Caltrain has issued an approval, and these specifications.
 - 2. Routine Flashover: A sampling of not less than 5 percent of each type of insulators shall be subjected to a flashover test in accordance with ANSI C29.1. For this test, an electrode shall be placed at each side of, and adjacent to, the non-ceramic barrier. Should any test specimen fail, all insulators in the production batch of that specimen are subject to rejection.

Alternatively, each insulator in the batch may be tested. Any insulators that puncture will be a cause to have the insulator design rejected.

3. Proof Test: Ten insulators of each insulator type shall be subject to a mechanical strength proof test. The insulators shall be tested at room temperature for ten seconds to 120 percent of the designed tensile, compressive or bending load. Failure shall constitute rejection.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. The insulators shall be installed in accordance with the Contract drawings and as specified in Section 34 30 85, OCS Installation.
- B. All factory tests shall be completed and test reports subsequently submitted to Caltrain for review and approval with a record copy sent to Caltrain prior to shipment of any insulators to the jobsite.
- C. Cantilever insulators shall be not be left to freely swing during wire stringing operations as to cause damage to any part of the insulator from support brackets, structure or equipment. Any damage caused to the insulator during construction shall be completely replaced by the Contractor at no additional cost to Caltrain.

END OF SECTION

SECTION 34 30 63

SECTION INSULATORS AND PHASE BREAKS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. This Section includes specifications for the supply, installation, and testing of section insulators and phase break assemblies for the Overhead Contact System (OCS), as shown on the Contract Drawings and specified herein. All section insulators and phase break assemblies furnished under this Contract shall be of proven design, with documented successful service history in similar railway applications of at least (5) years in service.
 - 1. Section insulators are units in the OCS which achieve electrical isolation while allowing physical clearance for the smooth passage of a pantograph.
 - 2. Bridging type section insulators used for sectionalizing purposes, as shown, shall permit continuous current collection.
 - 3. Non-Bridging type section insulators used for sectionalizing purposes (typically at Yards and Shops) and at Phase Break locations shall ensure the electrical isolation of adjacent sections of OCS during all phases of pantograph passage.

1.02 REFERENCE STANDARDS

- A. Pertinent Provisions of the latest revision of applicable NEMA, IEEE and ANSI Standards shall apply to the work of this Section, except as they may be modified herein, are hereby made a part of this Specification to the extent required.
- B. Section insulators may conform to the applicable European EN and IEC Standards in lieu of NEMA, IEEE, and ANSI Standards.
- C. IEC 61109 Insulators for Overhead lines- Composite suspension and tension insulators

1.03 QUALITY ASSURANCE

- A. Perform the Work included in this Section in strict accordance with the requirements of Section 01 43 00, Quality Control and Assurance.

1.04 SUBMITTALS

- A. Refer to Special Provisions Section 01 33 00, Submittal Procedures for review process.
- B. Submit the following information for approval, prior to fabrication:
 - 1. Insulators:
 - a. Electrical:

- i. Creepage length (inches)
 - ii. Insulation level (impulse withstand test voltage, kV)
 - iii. AC test voltage (kV)
 - b. Mechanical:
 - i. Attachment centers and overall length (inches)
 - ii. Insulator rod diameters (inches)
 - iii. Tensile test withstand breaking load (pounds)
 - iv. Recommended maximum working tensile load (pounds)
 - v. Material
 - vi. Torsional Strength (pounds)
 - vii. Maximum Speed Rating (kph, mph)
- 2. Manufacturer's design safety factors.
- 3. Shop drawings of hardware and components.
- 4. Listing and description of components and hardware.
- 5. Shop drawings and installation instructions required for field forming and setting of contact wire into mating items, including gliders.
- 6. For assemblies, list values of BIL, ultimate tensile strengths, ultimate torsional strength, weights (including weight of components), maximum speed rating, and electrical characteristics.
- C. Submit O&M Manuals covering complete instructions for the section insulator installation, operation, maintenance and testing. Provide a complete replacement parts list. Provide all manuals in accordance with the Contract Documents.
- D. Type Tests certificates for the insulators used shall be submitted with the tender and shall also be made available on request even if the insulators have been supplied previously. The contractor shall submit all type-test details, results, performance data and certificates to Caltrain. Submit reports for the field tests.
- E. Submit manufacturer full information, with supporting documentation, on the in-service performance history of the proposed section insulators.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Ensure that all section insulator materials are suitably protected against damage during transport, handling and storage.
- B. Store all products in accordance with the manufacturer's instructions, to ensure that all material is protected from damage and exposure.

- C. Handle and otherwise use the section insulators in accordance with the manufacturer's instructions, so as to ensure that the products are not damaged or misused prior to or during installation.
- D. Replace or repair damaged section insulators. All required repairs and replacements shall be accomplished in accordance with the manufacturer's instructions.
- E. Caltrain shall be allowed to inspect all materials, assemblies and hardware upon request to the Contractor.

PART 2 - PRODUCTS

2.01 PRODUCT CRITERIA

- A. Provide section insulators suitable for use in all styles and configurations of the Overhead Contact System. Section insulators shall remain stable (dynamically and structurally) under sustained crosswinds of up to 55 mph and withstand maximum crosswinds of 110 mph without failure or permanent deformation.
- B. Position section insulators, in general, adjacent to an OCS support point. Insulators are to be compatible with in-span installation requirements, providing the span lengths are suitable and messenger heights are sufficient to allow for the extra sag or used with an along track aerial head guy support cable. Provide arrangements of OCS showing the section insulator locations for approval.
- C. Provide section insulators capable of continuous operation at the nominal OCS voltage of 25 kV AC under all operational weather conditions specified for the project area.
- D. Assembly and component parts shall ensure ease of adjustment, maintenance, replacement, assembly, and disassembly with a minimum of specialized tools.
- E. Provide a riding overlap of the conductive runners on bridging type assemblies to ensure continuous current collection.
- F. Provide messenger insulation of non-ceramic material in accordance with Contract Documents.
- G. Provide contact wire insulator of glass fiber reinforced synthetic resin or polymer. Provide an insulator with 46 kV class insulation and with a BIL of 250 kV.
- H. Provide stabilizing hangers (with suitable means of field adjustment) from the messenger to restrict the rotational movement of the section insulator and to ensure correct alignment of the runners with respect to the pantograph.
- I. The interface and connection of the contact wire insulator to the runners shall permit a smooth riding path without pantograph carbon damage and dynamic collector bounce. The mass of the connection and the skids shall be as small as possible. Provide skids with field adjustment to achieve alignment with the pantograph and the contact wire. Section insulator "wish-bone" runners design shall not be allowed; unit must also support bi-directional train travel.
- J. Space the runners on the section insulator such that both sides are always in contact with the working portion of the pantograph.

- K. Insulators and their end fittings shall be suitable for the maximum working tensions of the conductors as shown. A factor of safety of 2.5 minimum, is required for all components of the section insulator.
- L. Provide lightweight components, particularly those associated with the contact wire.
- M. Provide insulators capable of operating with multiple pantographs passes at speeds from zero (0) to a maximum of 110 miles per hour on mainline and of the designed track speed at the crossovers, without sustaining damage or causing OCS operational problems.
- N. Arcing horns shall be provided, capable of sustaining arcs inadvertently drawn across the devices without damage other than electrical erosion of arcing horns.

2.02 MANUFACTURE

- A. Supply section insulator complete in all respects suitable for installation.
- B. Hot-dip galvanize all steel and malleable or ductile cast iron fittings in accordance with ASTM Specification A-153 or A-386. Accomplished prior to assembly of the section insulator.
- C. Testing:
 - 1. All tests shall be conducted by the manufacturer. Caltrain reserves the right to attend the tests. The Contractor shall inform Caltrain not less than 15 days in advance of testing operations. A certified test report shall be supplied whether or not Caltrain attends the tests.
 - 2. Provide test data or reference applicable field operational experience for the same product in a similar application. This performance history shall demonstrate that for a 5-year in-service period, all weather sheds material experiences no failure or detrimental effects from ultra-violet radiation and electrical tracking.
 - 3. The related messenger insulators (for section insulators not supported from an aerial head guy) shall be tension-proof tested in accordance with the applicable section of the Specifications, and all of the contact wire section insulator units shall be tension-proof tested to withstand 2.5 times the worst-case contact wire tension.
 - 4. Submit all test reports prior to shipment of any components.
 - 5. Test each type of section insulators for dry flashover, wet flashover, low frequency, dry and wet withstand and impulse withstand tests. Perform tests in accordance with applicable ANSI/IEEE and IEC 61109
 - 6. Electrical criteria shall be the same as for other insulators on the project, in accordance with the Contract Documents.

PART 3 - EXECUTION

3.01 GENERAL INSTALLATION REQUIREMENTS

- A. Refer to Section 34 30 85, OCS Installation.
- B. Contractor shall coordinate all phase break locations with Caltrain Operations and PTC system before train live run testing and commissioning of the system.

END OF SECTION

SECTION 34 30 65

OVERHEAD CONDUCTOR RAIL (OCR)

PART 1 - GENERAL

1.01 DESCRIPTION

- A. This technical specification outlines the requirements for the design, supply, installation, testing, and commissioning of the rigid overhead conductor rail (OCR) system, also known as the rigid overhead contact rail (OCR) system. It is the Contractor's responsibility to fulfill the General Requirements presented in this Section and ensure compliance with all applicable codes, standards, and best practices for safe, reliable operation in tunnel environments.
- B. General Requirements
1. The scope of work to fulfill the requirements of this Section is as follows:
 - a. Provide a complete rigid contact rail system, complete with dimensioned shop drawings, bills of materials, parts lists, recommended spare parts list, factory certified type test reports for product having the same design requirements, and all other necessary information for installation, commissioning, and operation & maintenance.
 - b. Document and submit the methodology, calculations, and results in support of the installation details. The documentation shall include applicable design calculations for thermal expansion, maximum support spacing, structural support, deflection, contact surface gradients, bend radius, current-carrying capacity, and corrosion prevention, aligned with IEEE and AREMA Standards.
 - c. In addition, assume final design responsibility and give due regard to the design criteria, as well as the environmental, health and safety issues as required and outlined.
 - d. OCR design considerations shall be made for mitigation of tunnel leaks, corrosive environment, calcification deposits and stalactites.
 2. Assume responsibility for all aspects of the OCR system, its design and the assembled system will provide a safe and reliable operation over a 40-year service life.
 - a. European Standards shall apply to OCS Rigid Contact Rail System.
 3. Furnish and install the complete rigid OCR rail system, including all miscellaneous materials for its support.
 4. Furnish materials necessary to complete the interface of the OCR system with the simple catenary overhead contact system.

5. Provide field testing of the installed system.
 6. Provide commissioning of the installed system commissioned after any interface work performed by other projects or other Caltrain Contractors. The entire overhead catenary system shall be fully adjusted and tested in place.
- C. Drawing Units
- a. Contractor to submit Shop Drawings that are drawn to scale and are completely dimensioned in imperial units. Dimensions are to be shown in decimals of a foot or decimals of an inch.
- D. Design Change
1. Having studied the drawings and design performance criteria, the Contractor may request a change to the design, if the change would make the design safer, more cost effective, or improved, or if changes are required to meet the performance criteria or any other requirements specified in this document.
 2. Any and all requests for changes to the design must be made in writing to the Caltrain for review. Plan on the Caltrain's review of the design change taking a minimum of 28 days from the date of receipt by the Caltrain before any design changes are incorporated into the final design documentation. Caltrain reserves the right to reject any requests for change to the design without being obliged to justify the decision.
- E. Drawing Schedule
1. Supply a drawing schedule of shop drawings proposed to be submitted for approval in accordance with Section 01 33 00, Submittal Procedures.
- F. Site Supervision: assume full responsibility for the management and implementation of all site work.

1.02 REFERENCES

- A. CPUC GO-95
- B. CPUC SED-2 – Safety Requirements Governing the Design, Construction, Installation, Operation, and Maintenance of the 25 kV AC (Alternating Current) Railroad Electrification System of the Peninsula Corridor Joint Powers Board (Caltrain) on the San Francisco Peninsula Rail Corridor
- C. Institute of Electrical and Electronic Engineers (IEEE)
- D. NESC C-2 – National Electrical Safety Code

- E. EN 50119 Railway Applications – Fixed Installation – Electric Traction Overhead Contact Lines

1.03 INTERFACES

- A. The Contractor shall provide to the Caltrain for approval, all shop drawings indicating points of interface with other sub-systems and the existing structures.
- B. It is the Contractor's responsibility to verify all field measurements
 - 1. Be fully cognizant that by approving and submitting shop drawings, samples, and product data, contractor thereby represent that it has been determined and verified, that all field measurements, field construction criteria, materials, catalogue numbers, and similar data, have been checked and each shop drawing and sample has been coordinated with the requirements of the work and the contract documents.
 - 2. Assume responsibility for the accuracy of all shop drawing submittals and approval of such shop drawings shall indicate that contractor/designers have reviewed them for accuracy and adherence to the design criteria.

1.04 QUALITY ASSURANCE

- A. Quality Assurance Program
 - 1. Submit proof that a quality assurance system for the manufacturing of the OCR system is in place, as required by Section 01 43 00, Quality Control and Assurance.
 - 2. Provide a compilation of spare parts list and related literature which fully identifies all parts of the equipment at the final as-built stage, as required, the part number of the original equipment manufacturer.

PART 2 - PRODUCTS

2.01 MATERIALS AND ASSEMBLIES:

- A. The rigid Overhead Conductor Rail (OCR) system shall be provided by a single industry-recognized vendor with a proven record of successful installations. The system shall be suitable for the maximum train speed, which shall be 110 mph on the main line and/or track design speed of the site.
- B. The list of system assemblies to be provided shall include, but not limited to, the following:
 - 1. Conductor rail support, including drop tubes and tunnel mounting plates and bolts to affix the drop tubes to the tunnel ceiling insulators.
 - 2. Rigid bars for conductor rail, including joints, position adjustors and support insulators.

3. Interlocking joints for conductor rail, as required.
4. Transition bars for conductor rail.
5. Protective plastic covers for conductor rail.
6. Conductor rail end sections.
7. ATF and SW attachments.
8. Anchor plates for conductor rail, as required.
9. Fixed point plates for conductor rail, as required.
10. Conductor rail expansion joints, as required.
11. Conductor rail mid-point anchor, as required.
12. Contact wire to be fitted in the conductor rail

PART 3 - EXECUTION

3.01 SITE SUPERVISION

- A. The work shall be performed under the supervision of a representative of the OCS conductor rail system manufacturer.

INSTALLATION TOLERANCES:

Contact wire stagger – open route +/- 1 inch

Contact wire height – Mainline transition +/- 0.5 inch

Contact Wire Height – Mainline level +/- 1 inch.

Contact Wire height through transition has to follow maximum design gradient within the transition and half this value for two consecutive spans. Contact wire height difference between two consecutive spans, on flat level, shall not exceed half the maximum design gradient corresponding to the speed limit.

Contact wire stagger shall be relative to design track centerline at time of footing or drop tube supports installation.

3.02 DRILLING

Post installation drilling shall be avoided in the tunnel linings of new tunnels because of health and safety hazards. The design shall incorporate the prefabricated/preinstalled ferrules in the tunnel linings for OCR fittings. However, in the existing tunnels drilling for anchor bolts in the tunnel roof to support the conductor rail system shall be as follows:

- A. Hole patterns shall be drilled in parallel and in alignment to the tracks.

- B. The tolerances for drilling patterns shall be provided by a system vendor.
- C. Holes shall be drilled perpendicular to the roof of the tunnel.
- D. If an anchor bolt hole is drilled but found to be unusable due to spalling of concrete or bricks, adjust the location of the support and patch the damaged hole in a manner approved by Caltrain.

3.03 CONTACT WIRE INSERTION

- A. Contact wire shall be inserted into the rigid conductor rail, using a specialized device provided by the conductor rail system manufacturer. Protective grease shall be supplied by the conductor rail system manufacturer and applied to the contact wire during the process of contact wire insertion to prevent galvanic action between the aluminum rigid rail and the copper wire.

END OF SECTION

SECTION 34 30 69**BALANCE WEIGHT AND MIDPOINT ANCHOR ASSEMBLY****PART 1 - GENERAL****1.01 DESCRIPTION**

- A. This Section includes specifications for the design, manufacture, testing, supply, and installation of the balance weight anchor equipment, and mid-point anchor assemblies for the Overhead Contact System (OCS), as shown on the Caltrain standard drawings and specified herein.
- B. The Balance Weight Anchor (BWA) assemblies automatically regulate the tension of the Simple Catenary Auto Tensioned (SCAT) system by compensating for variations in conductor lengths resulting from changes in temperature due to ambient, solar and electrical heating variations.
- C. For a full wire run tension length, a Mid-Point Anchor (MPA) assembly is typically located approximately one-half of the distance between the termination ends (where the BWA are located) and serves to secure the messenger wire and contact wire from along-track movement at this central point. This effectively divides the full wire run length into two (2) "half-tension" lengths between the MPA and the BWA at each end. In addition, half-tension length wire runs are utilized where BWA are located at one termination end and Fixed Termination Anchors (FTA's) are positioned at the other wire run termination. Half tension runs of this configuration do not use an MPA assembly.

1.02 REFERENCE STANDARDS

- A. American Society for Testing and Materials (ASTM)
 - 1. A27, Specification for Steel Castings, Carbon, for General Application.
 - 2. A572, Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.
 - 3. A47, Specification for Ferritic Malleable Iron Castings.
 - 4. A123, Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - 5. A153, Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 - 6. A240, Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
 - 7. A307, Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength.
 - 8. A518, Specification for Corrosion-Resistant High-Silicon Iron Castings.
 - 9. A536, Specification for Ductile Iron Castings.

10. A668, Specification for Steel Forgings, Carbon and Alloy, for General Industrial Use.
 11. A711M-17, Specification for Steel Forging Stock.
- B. The BWA may be manufactured in accordance with applicable IEC and EN standards in lieu of the ASTM standards indicated above.

1.03 QUALITY ASSURANCE

- A. Perform the Work included in this Section in strict accordance with Section 01 43 00, Quality Control and Assurance.

1.04 SUBMITTALS

- A. Refer to Special Provisions Section 01 33 00, Submittal Procedures for review process.
- B. Submit the following Shop Drawings and list of special tools as follows:
1. A complete set of Shop Drawings showing the BWA unit assemblies, all components, and a Bill of Material giving dimensions, weights, manufacturer country of origin, and related design and product data. Appropriate shop drawing and site-specific installation charts shall be provided for each BWA units supplied.
 2. List of special tools, required for the BWA assemblies and installation.
- C. Provide supplier's certificate of compliance accompany each shipment of a BWA assembly. As a minimum, it shall contain the following:
1. Product Name
 2. Drawing Number and revision or date
 3. Quantity
 4. Purchase Order Number
 5. List of specifications to which the product was produced
 6. Supplier's name and address
 7. Signature and title of recognized quality authority
- D. All factory and other test reports as indicated shall be submitted.
- E. Operation and maintenance data for BWA shall be provided.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Package OCS BWA assemblies in a manner to allow stacking and outdoor storage until installation with no harmful effects.

PART 2 - PRODUCTS**2.01 PERFORMANCE REQUIREMENTS**

- A. The BWA assembly shall maintain essentially constant tension in the conductors to compensate for changes in ambient, solar or current heating temperatures. Changes in the lengths of conductors shall be compensated for by an equivalent change in the position of the balance weight stack. The BWA assembly shall accommodate vertical movement of the weights due to OCS behavior at conditions from 20° F (no ice) to 145° F.
- B. The BWA wheel assembly shall have an effective 1:3 ratio suitable for the wire rope types used to achieve operation over the required temperature range.
- C. The BWA assembly shall be suitable for the wire rope types used and shall be equipped with weatherproof bearings rated for outdoor (exposed) use in San Francisco to San Jose, California environment.
- D. The BWA assembly shall operate freely under all climatic conditions within the limits specified.
- E. Balance weights shall be fabricated of cast iron or malleable iron casting, with a vandal proof assembly.
- F. Weight sets are to be individual castings. Individual castings shall be of an interlocking design to prevent slippage. The assembled stack of weights shall be cylindrical in shape. An acceptable alternative is to cast weight as a single cylindrical member. Internal weight stacks within a pole structure is not allowed.
- G. Tolerance on the complete balance weight stack shall be 0 lbs to +50 lbs.
- H. Weights shall be compact, allowing for the required vertical movements provided by the available length of the support pole.
- I. The BWA assembly shall have a minimum design life of 40 years and shall not normally require preventative maintenance or inspection at intervals of less than 12 months. The BWA design shall permit access to the weight stack during installation and subsequent maintenance. The BWA assembly shall be suitable to maintain a constant tension of 12 kN (2,700 lbf) in the messenger wire and 14 kN (3,150 lbf) in the contact wire at temperature conditions indicated in Paragraph 2.1.A above.
- J. Assemblies and component parts shall be designed for ease of maintenance, replacement, assembly, and disassembly, which shall be accomplished with a minimum of special tools. Component parts shall be properly identified for this purpose. All special tools required to service and maintain the BWA assembly shall be provided.
- K. Incorporate provisions for adjustment due to wire elongation (stretch).
- L. All materials and the unit design shall have been proven by the manufacturer's experience to be suitable for the purpose for which they are intended. They shall be suitable for the loads and climatic conditions existing in the project as noted in the Contract Documents.

- M. All external ferrous parts shall be stainless steel or hot-dip galvanized in accordance with the appropriate ASTM specification. Any ferrous parts which are not stainless steel shall be hot-dipped galvanized.

2.02 TESTING

- A. Inspect and factory test the BWA assemblies to ensure that they satisfy the requirements noted in the Contract Documents and shop drawings. Submit a test report certifying these requirements.
- B. Submit copy of Type Tests including Fatigue Tests and Release Tests.

PART 3 - EXECUTION

3.01 GENERAL INSTALLATION REQUIREMENTS

- A. Refer to Section 34 30 85, OCS Installation.
- B. Contractor shall ensure that the manufacturer's design of the weight stack does not interfere with cantilever buckets under normal operation. Balance weight stack shall have unimpeded movement across its full operating range.

END OF SECTION

SECTION 34 30 73

OCS FITTINGS AND HARDWARE

PART 1 - GENERAL

1.01 DESCRIPTION

A. This Section includes specifications for the supply and installation of ferrous and non-ferrous metallic components, line material, hardware and fittings for the Overhead Contact System (OCS), as shown on the Contract Drawings and specified herein. The Work includes but is not limited to the following:

1. Hanger Assemblies
2. Wire Cross Assemblies
3. Wire Splices
4. Clevis-Clevis Fittings
5. Wire Terminations
6. Parallel Wire Clamps
7. Nuts, Bolts, Washers and Cotter Pins
8. Messenger Wire Dead Ends
9. Links, Straps and Eyebolts
10. Messenger and Contact Wire Terminations
11. Double Clevis End Fittings
12. Thimbles and Turnbuckles
13. Wire Sleeves
14. Messenger Suspension Clamps and Span Wire Supports
15. Wire Clamps
16. Wire Connectors and Saddles
17. Wire Adjustable Straps
18. Strain Clamps
19. Knuckle Assemblies and Wire Spacers
20. Trunnion Clamps
21. Pole Bands and Connectors

- B. Other specialized fittings, hardware, and assemblies necessary to erect the complete OCS system, including counterweights and fixed-end terminations, cantilevers, OCS support assemblies, registration arms, pull-off/push-off steady arms, downguys, section insulators, disconnect switches, surge arrestors, bridge OCS supports, brackets and hinges, balance weight assemblies, contact wire crossing assemblies, warning signs, I.D. numbers, and information markers.

1.02 REFERENCE STANDARDS

- A. Codes and Standards: Pertinent provisions of the following listed standards shall apply to the work of this Section, except as they may be modified herein and are hereby made a part of this Specification to the extent required. Materials and components manufactured to applicable foreign standards, including metric standards, are acceptable, provided that written evidence, in the English language, demonstrates they are equal or superior to those complying with the standards listed, and that written approval is obtained from Caltrain. Weights and dimensions shall be provided in both Metric/English units where necessary.

1. Ferrous Metals:

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

- i. A27, Specification for Steel Castings, Carbon, for General Application.
- ii. A47M-99R22, Specification for Ferritic Malleable Iron Castings.
- iii. A153, Specification for Zinc coating (Hot-Dip) on Iron and Steel Hardware.
- iv. A193 Grade B7, Specification for Alloy-Steel and Stainless-Steel Bolting for High Temperature or High-Pressure Service and Other Special Purpose Applications.
- v. A528M-99(2022), Standard Specification for Corrosion-Resistant High-Silicon Iron Castings
- vi. A668M-23, Specification for Steel Forgings, Carbon and Alloy, for General Industrial Use.
- vii. A711M-17(2022), Standard Specification for Steel Forging Stock.
- viii. A747M-23, Specification for Steel Castings, Stainless, Precipitation Hardening.

2. Non-Ferrous Metals:

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

- i. B26, Specification for Aluminum-Alloy Sand Castings.
- ii. B148, Specification for Aluminum-Bronze Sand Castings.

- iii. B179, Specification for Aluminum Alloys in Ingot and Molten Forms for Castings from All Casting Processes.
 - iv. B248, Specification for General Requirements for Wrought Copper and Copper-Alloy Plate, Sheet, Strips and Rolled Bar.
 - v. B249, Specification for General Requirements for Wrought Copper and Copper-Alloy Rod, Bar and Shapes.
 - vi. B557, Test Methods for Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products.
 - vii. B584, Specification for Copper Alloy Sand Castings for General Applications.
 - viii. B686M-18, Specification for Aluminum Alloy Castings, High-Strength.
- B. OCS fittings and hardware may be manufactured in accordance with applicable DIN and EN standards in lieu of the ASTM standards indicated above. Wherever possible use fittings and hardware of Imperial System (English units).

1.03 QUALITY ASSURANCE

Perform the Work included in this Section in strict accordance with the requirements of Section 01 43 00, Quality Control and Assurance and Section 34 30 03.

1.04 SUBMITTALS

- A. Refer to Special Provisions Section 01 33 00, Submittal Procedures for review process.
- B. Submit Shop Drawings for all OCS hardware assemblies and components, prior to manufacture, showing details and dimensions, and giving designations of the materials comprising the various components together with technical, mechanical and electrical data as appropriate.
- C. Submit to Caltrain or make available at the warehouse one sample for each of the major assemblies and components listed below.
 - 1. Messenger wire saddles
 - 2. Contact wire clamps
 - 3. Hanger assemblies
 - 4. Wire splices
 - 5. Messenger suspension clamps
 - 6. Messenger span wire supports
 - 7. Messenger and contact wire terminations

- 8. Parallel wire/Groove clamps
- D. Provide operational (installation) and maintenance data, including specified fastener torque requirements, all components addressed in this Section and/or utilized in the work.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Assembly, component, and fitting materials shall be packaged, stored, handled, and transported in a manner that will prevent damage occurring to the material and any surface coatings.
- B. Cast the identification mark of the manufacturer or foundry and the pattern numbers assigned by the supplier into all castings. Marks and numbers shall be readable size, and in such a position that they will not affect their electrical or mechanical performance.
- C. Pack fittings and hardware in accordance with the best commercial practice, adequate to ensure acceptance and safe delivery.
- D. Mark all shipping boxes, bags, or crates showing the contents of each. If different materials are packaged in a box, bag or crate all items of a kind should be boxed, bagged or crated and properly marked or tagged prior to placement in the shipping vessel. Different components shall not be layered on top of each other within shipping crates; manufacturers shall segregate the components for ease of inspection by Caltrain.
- E. Pack OCS fittings and hardware in a manner to allow stacking and outdoor storage until final installation with no harmful effects.
- F. Materials shall not be stored in contact with the ground. They shall be stored in a manner and location that will not cause deterioration of the material. They shall be labeled clearly and numbered to match the approved design drawings.
- G. Materials shall be delivered to site at a rate and in a manner that will ensure uninterrupted work.
- H. Any damage to the materials and equipment shall be the responsibility of the party causing the damage, and all repairs shall be accomplished in accordance with the manufacturer's instructions, at no additional cost.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Material for hardware and fittings shall comply with the applicable standards. Substitutions will be considered if the requirements of the Contract Documents are satisfied, subject to Caltrain's review and approval. Hardware and fittings shall satisfy the complete form, fit and function of all OCS components and hardware which make up the OCS assemblies and equipment, as shown on the Contract Drawings.
- B. All materials and components used in the OCS assemblies shall be of sufficient strength and durability to withstand the calculated loads with addition of a

minimum factor of safety of 2.5. Messenger and contact wire fasteners and terminations shall meet a factor of safety of 2.0. The factor of safety shall be greater than 2.5 when indicated in the Contract Documents and where recommended by the manufacturer.

- C. Optional hardware may be installed such as turnbuckles and guy grips, may not be indicated on the Contract Documents or assembly shop drawings, to facilitate installation. The strength and quality of this optional hardware shall meet or exceed the strength and quality of the other hardware in the assembly. The introduction of this optional hardware shall not alter the function of the completed assembly. All optional hardware shall be submitted for Caltrain's review through the shop drawing process prior to their supply and installation with a record copy sent to Caltrain.

2.02 METAL CHARACTERISTICS

- A. Metal fittings and hardware shall be manufactured in accordance with applicable DIN, EN standards or ASTM Standards.
- B. For metal fittings and hardware conforming to ASTM Standards, requirements shall be as follows:
 - 1. Provide malleable iron fittings or components conforming to grade 32510, or better, and to ASTM A47M-99R22. Galvanize all components and fittings in accordance with ASTM A153.
 - 2. Material for forged steel shall comply with ASTM A711M-17(2022) or A668M-23. Galvanize all components and fittings in accordance with ASTM A153.
 - 3. Provide fittings or components requiring high yield strength having a ductile iron, grade 60.40.18 or fittings and components conforming to ASTM A536-24. Galvanize all fittings and components in accordance with ASTM A153.
 - 4. Stainless Steel hardware shall conform to ASTM A747M-23.
 - 5. Copper alloys for fittings and components shall conform to ASTM B584 and B148.
 - 6. All copper components shall conform to ASTM B248 or B249. Aluminum components shall conform to ASTM B26, B557 and B686.
- C. All cotter pins, roll pins, spring clips and hitch pins, shall be made out of stainless steel.

2.03 FABRICATION

- A. The designated metals shall be produced by a method that will meet the requirements of this Section.
- B. Castings shall be of uniform quality and shall be made in such a manner that the material of the casting conforms to the chemical and mechanical properties prescribed in the ASTM standards referenced.

2.04 WORKMANSHIP, FINISH, AND APPEARANCE

- A. The castings shall be free of adhering sand, voids, cracks, surface porosity and non-uniform dimensions.
- B. The form, function and fit, including the dimensional accuracy of all OCS assemblies, equipment fittings and hardware shall be complied with the Contract Documents.
- C. Repairs to fittings and hardware shall be permitted only to the extent allowed by the applicable ASTM, IEC, or EN standards. Obtain approval from Caltrain prior to accomplishing any repair.
- D. Malleable iron, ductile iron, forged steel and mild steel components in contact with the pole surface (if other than galvanized) shall be painted to match the finish of the pole. Should galvanized components be furnished, the paint system used shall be compatible with the galvanizing.

PART 3 - EXECUTION

3.01 INSTALLATION REQUIREMENTS

- A. Installation requirements for OCS fittings and hardware shall be in accordance with the manufacturer's recommendations, Master Specifications and the Contract Documents.
- B. The manufacturer's recommended installation practice shall be followed. Information in these Specifications shall be incorporated and accounted for by the manufacturer's recommended installation practices. All installation shall be in accordance with the requirements in these Specifications, state and local regulations.
- C. Drilling, cutting, or reaming of components will not be permitted without prior approval by Caltrain.

3.02 COMPONENT PERFORMANCE AND USABILITY

- A. All fittings and hardware used for the OCS assemblies shall be selected and made such that they can be reused after removal (except for pole banding, wire splices and compression sleeves and caps).
- B. All fittings and hardware shall be designed for easy interface with the other components of the electrification system.
- C. All fittings and hardware shall be designed to provide a fully functional, homogenous OCS hardware and assembly arrangement.
- D. Components and assemblies shall be designed such that all fastenings and adjustments are accomplished with the same dimensional standards or tools.

END OF SECTION

SECTION 34 30 76 OCS DISCONNECT SWITCHES

PART 1 - GENERAL

1.01 DESCRIPTION

- A. This Section specifies requirements for the design, procurement, manufacture, factory testing, shipment, and installation of overhead line disconnect switches and associated equipment, including supports, motorized and manual operating units, and drive pipes, for sectionalization of the 2 x 25 kV AC, 60 Hz Overhead Contact System (OCS). Equipment shall be supplied as shown on the Contract Drawings and specified herein.
 - 1. The Contractor shall prepare detailed shop drawings for each required disconnect switch assemblies, based on the general concepts specified in the standard drawings and the information stated in this Section.
 - 2. This Section covers single-pole and double-pole motorized and manually operated switches.
- B. This Section does not cover 25 kV switchgear at Traction Power Facilities. See Specification Section 34 31 66 for switches at Traction Power Facilities.

1.02 REFERENCE STANDARDS

- A. Pertinent provisions of the following listed standards shall apply to the work of this Section, except as they may be modified herein, and are hereby made a part of this Specification to the extent required:
 - 1. Institute of Electrical and Electronics Engineers (IEEE):
 - a. C37.30.1, Standard Requirements for High-Voltage Switches.
 - 2. American Society for Testing and Materials (ASTM):
 - a. B187, Specification for Copper, Bus Bar, Rod, and Shapes and General Purpose Rod, Bar, and Shapes.
 - 3. National Electrical Manufacturers Association (NEMA):
 - a. ICS 1, Industrial Control and Systems: General Requirements.
 - b. ICS 2, Industrial Control and Systems: Controllers, Contactors and Overload Relays rated 600 Volts.
 - 4. National Fire Protection Association (NFPA):
 - a. National Electrical Code (NEC)

1.03 QUALITY ASSURANCE

- A. Perform the work included in this Section in strict accordance with the requirements of Section 01 43 00, Quality Control and Assurance.

1.04 SUBMITTALS

- A. Refer to Special Provisions Section 01 33 00, Submittal Procedures for review process.

- B. Submit the following information prior to fabrication:

- 1. Disconnect Switches:

- a. Fully detailed technical specifications of disconnect switch, with dimensioned outline drawings which fully exhibit the principal features of the switch equipment. These drawings shall clearly indicate what provision will be made for fixing the isolator base to the supporting steel work.
- b. Details of the electrical ratings of the disconnect switch.
- c. Dimensioned outline drawings which fully exhibit the principal physical features of the switch equipment.

- 2. Operating Mechanisms:

- a. Fully detailed drawings of each type of operating mechanism for motor and manual operated switches showing the overall dimensions, and the means of securing to the supporting structure.
- b. For motorized operating mechanism, provide the specifications for:
 - i. Rated supply voltage.
 - ii. Current required at rated supply voltage to operate the isolator.
 - iii. Operating time (maximum opening or closing time not to exceed 6 seconds under normal conditions).
 - iv. Insulation rating.
 - v. Full load power rating of motor at rated voltage.
 - vi. Power rating of anti-condensation heater.
 - vii. Current interrupting capability.

- 3. Insulators:

- a. A general Specification of each different type of insulator, including:
 - i. Electrical and mechanical ratings.

- ii. Dimensioned outline drawings which fully illustrate the principal physical features of the insulators.
- 4. Guides:
 - a. A drawing of the drive pipe guide, indicating what provision will be made for fixing the guide to the supporting structure.
 - b. Number and spacing of guides required for each drive pipe.
 - c. Guide pipe couplers required for avoiding obstructions from other equipment.
- 5. Operation & Maintenance Manual:
 - a. Copies of the installation, operation and maintenance manual shall be provided for the proposed disconnect switches, in accordance with Section 34 30 93, OCS Manuals and Training.
 - b. Additionally, one (1) complete set of as-built drawings and the installation, operation and maintenance manuals shall be supplied with each disconnect switch unit within a water-sealed folder mounted to the inside of the front door.
- C. Submit requirements and production/factory tests reports within 1 week after completion of each component testing procedure.

1.05 FACTORY TESTS

- A. General: Disconnect switches shall be tested at the factory prior to shipment, as specified herein.
- B. Type Tests:
 - 1. Disconnect Switches:
 - a. Tests to verify the insulation level
 - b. Tests to prove that the temperature rise of any part does not exceed the values specified
 - c. Tests to prove the capability of the switch to carry the rated short time current
 - d. Tests to prove satisfactory operation and mechanical endurance (1,000 operations minimum per IEEE C37.30.1)
 - 2. Electric Motors:
 - a. Provide tests in accordance with the requirements of the relevant references.
 - b. Fully detailed Type testing reports must be provided.

3. Where these tests have previously been undertaken on equipment similar in all respects, likely to affect its performance during a particular test or series of tests, Type Test Certificates may be submitted for acceptance.
 4. Perform tests in accordance with IEEE testing standards, and the manufacturer shall clearly list its testing procedures and references of standards.
- C. Sample Tests:
1. Sample tests to be carried out at the manufacturer's factory in accordance with the routine tests noted below. The responsibility for inspection of all components in accordance with the appropriate specifications is delegated to the manufacturer, but the Contractor and Caltrain reserve the right to witness the inspection and testing.
 2. The following routine tests shall be carried out:
 - a. Power-frequency voltage dry tests of the main circuit.
 - b. Measurement of the resistances of the main circuit.
 3. Perform tests in accordance with IEEE testing standards, and the manufacturer shall clearly list his testing procedures and references of standards.

PART 2 - PRODUCTS

2.01 GENERAL

- A. The Overhead Contact System is a 2 x 25 kV AC system. The OCS conductors will be energized at a nominal single phase voltage of +25 kV to rail. Maximum Line-to-Line Voltage is 55 kV. Maximum Line-to-Ground Voltage is 27.5 kV. The 25 kV disconnects shall be single pole or double pole type as indicated in the Contract Documents and/or OCS design.
- B. Locate disconnect switches on designated catenary poles along the mainline electrified railroad. Switches shall be designed to withstand the conditions specified in Section 34 30 03, OCS General Requirements.
- C. Owing to the exposed nature of the system, frequent short circuits of varying severity are likely to occur. The switch equipment supplied shall withstand the effects of any short circuits up to the maximum value 38 kA for 3 seconds for a 1200A switch, unless otherwise noted.
- D. It is expected that the switch equipment will be subjected to some ground vibration during the passage of trains. All switch equipment shall be designed to withstand such vibration. Experience with similar switch equipment on railway installations is required.
- E. Replaceable parts shall be interchangeable.
- F. Adequately ground all switch equipment to ensure the protection of the equipment and the safety of those concerned in its operation and maintenance.

2.02 SWITCH TYPES AND RATINGS

- A. Switch Type Reference:
 - 1. Type A1 – Double Pole, 55 kV Line to Line, 27.5 kV Line to Ground, Open/Close
 - 2. Type B1 or B2 – Single Pole, 27.5 kV Line to Ground, Open/Close
- B. Provide disconnect switches, manually or remote motor operated, depending on the application.
- C. Details of the operating mechanisms are given below in paragraphs 2.3 E, F and G. Switches will remain in the same operating position (open or close) for long periods of time without being operated.
- D. Ratings: Disconnect switches shall comply with the following:

1.	Rated Normal Current	Type A1	1200A
		Type B1	1200A
		Type B2	600A
2.	Rated 3 sec. Short Time Current:	38 kA for 1200A Switch	
		25 kA for 600A Switch	
3.	Momentary asymmetrical current rating	61 kA for 1200A Switch	
		40 kA for 600A Switch	
4.	Pole spacing	52 inches	
5.	Frequency	60 Hz	
6.	Voltage Class	46 kV	
- E. Switches shall have limited current interrupting capability as follows:

1.	Current interrupting capability	600A
2.	Emergency interrupting capability	900A

2.03 CONSTRUCTION

- A. Insulation:
 - 1. Provide cylindrical post insulators in accordance with ANSI standards and shall be capable of withstanding all mechanical loads imposed during switch operation. Insulators shall comply with the following electrical requirements:
 - a. Basic Lightning Impulse:

- i. BIL: 250 kV
 - ii. Leakage Distance: 43 in.
 - b. The insulation level of the disconnect switch (48.3 kV rms maximum voltage) shall comply with the following requirements:
 - i. Dry impulse withstand voltage minimum 250 kV
 - ii. Wet withstand voltage, 10 sec minimum 100 kV
 - iii. Dry withstand voltage, 1min. minimum 120 kV
- B. Contacts:
 - 1. The moving blade shall be of copper or aluminum with tinned contact surfaces.
 - 2. Disconnect switches shall have fixed jaws with replaceable tinned copper contacts.
 - 3. Provisions shall be made for coarse and fine adjustments of the contacts within the housing.
 - 4. A mechanical stop shall be incorporated within the assembly to prevent over-travel of the isolator blade tip.
- C. Couplings:
 - 1. Disconnect switches shall incorporate all components necessary for connecting to the drive pipe (operating rod).
- D. Special Requirements:
 - 1. Any bearing assemblies shall, when necessary, be packed with grease and adequately sealed against the ingress of moisture and other contaminants.
 - 2. The base of any moving insulator shall be electrically bonded to the main base of the switch in order to ensure a low resistance path for fault current. The connection should be made with a flexible conductor of sufficient size to withstand the rated short time current.
 - 3. Disconnect switches shall be designed so that the drive pipe acts on the moving part through an insulator. The drive pipe shall be bonded.
- E. Drive Pipes:
 - 1. Drive pipes shall be of galvanized heavy steel pipe for use with pole-mounted switch.
 - 2. The drive pipes shall be supplied complete with all necessary guides.

- F. Manual Operator (Open/Close):
 - 1. Operation shall be by means of a handle (lever). When not operating, handle shall be folded in a vertical plane.
 - 2. The mechanisms shall be such that the handle is in the lowered position when the switch is open and in the raised position when the switch is closed.
 - 3. The handle shall have definite "ON" and "OFF" positions which shall be clearly labeled.
 - 4. Provisions shall be made to secure the handle in either operating position using a single padlock.
 - 5. The manual operator shall incorporate all components necessary for connecting to the drive pipe.

- G. Motorized Operating Unit:
 - 1. General:
 - a. Disconnect switches with motorized operating units shall be configured to permit remote monitoring and control by means of a SCADA System.
 - b. The SCADA system will remotely switch power to initiate the disconnect switch operation via interposing relays.
 - c. Refer to the Communications and Traction Power Systems Specifications sections of the SCADA Remote Terminal Unit (RTU) and the control cables connecting between the RTU and the motorized operating unit. The SCADA headend equipment will be by others.
 - 2. Power Supply:
 - a. The power supply to the motorized operating unit will be 125V DC for control and monitoring.
 - b. The 125V DC will be delivered from a central Wayside Power Cubicle at each interlocking.
 - c. External cables and 125V DC source is not part of this Section.
 - d. The motorized operating unit shall be capable of functioning correctly for a supply voltage anywhere within the ANSI specified control voltage range.
 - 3. Motorized Operation:
 - a. Push buttons shall be provided inside the normally locked operating unit for the purpose of operating the switch locally.

- b. A changeover switch shall be provided to select local or remote control. The selector switch shall also provide spare contacts for remote indication via the SCADA system.
 - c. The design of the unit shall be such that once a motorized operation has been initiated, that operation will be completed.
 - d. The maximum opening time or closing time shall not exceed 6 seconds during normal operating conditions.
 - e. Provisions for manual operation of the motorized switch must be provided for use in case of loss of power to switch.
4. Limit Switches and Remote Indication Facilities:
- a. Limit switches, actuated according to the position of the output shaft, shall be provided as required for correct motorized operation of the disconnect switch. Additionally, 4 (four) fully reversible voltage free contacts shall be provided for the purpose of remote indication of the disconnect switch status.
 - b. These contacts shall have a minimum rating of 10A @250 V.
5. Enclosures:
- a. The motorized operating units shall be housed in weatherproof (NEMA) enclosures of rating 4X. Surfaces shall be protected by galvanizing, or, subject to agreement, by a suitable alternative treatment affording a similar degree of protection.
 - b. The enclosure shall incorporate a door type front panel which is opened by turning a handle. The front panel shall incorporate provision for locking in the closed position.
 - c. The front panel shall be interlocked with the operations handle to prevent the opening when the switch is closed.
 - d. The enclosure shall have ventilation apertures which prevent the ingress of vermin and insects. The apertures shall be suitably louvered externally to prevent the ingress of water.
 - e. Provision shall be made in the base of the enclosure for the accommodation of the incoming cables.
 - f. The enclosure shall be designed to give easy access to all sub-assemblies by removable internal panels.
6. Anti-Condensation Heater:
- a. The motorized operating unit shall incorporate a 110 V/240V AC 60Hz anti-condensation heater of suitable power rating.
7. Protection Devices:

- a. Separate fuses shall be provided for the motor circuit and the control circuit.
 - b. For each of the three circuits referred to in Paragraph G.6.a and G.7.a, fuses shall be provided.
 - c. The motor circuit shall incorporate a thermal cut-out to protect the motor against overloads.
 - d. A system shall be incorporated to prevent the operation under excessive torque.
8. Labels:
- a. Provide labels to indicate clearly whether the switch is in the "CLOSED" or "OPEN" position.
 - b. A suitably inscribed plate giving instructions for manual operating shall be fixed within the operating unit enclosure in an easily read position.
9. Couplings:
- a. Supply each motorized operating unit complete with all components necessary for connection of the drive pole.
10. Special Requirements:
- a. The motorized operating unit shall be fitted with an internal locking device to secure the switch in either position. The locking device shall incorporate a switch which interrupts the motor circuit when the isolator is locked in either position.
 - b. Suitable terminal blocks for connecting all incoming cables shall be provided in an accessible position in the motorized operating unit. All internal wiring and cable terminations associated with the operating unit shall be supplied by the manufacturer.
- H. Provide line and load side disconnect switch terminals furnished with silver plated copper buses complying with ASTM B187, to accommodate the number and size of copper cables as indicated on the Contract Drawings. The switch terminals shall have provision for NEMA drilled (2-hole or 4-hole) cable terminal lugs.
- I. Provide each disconnect switch manual operating handle or motor operator cabinet with an outdoor type, heavy duty, keyed padlock having a hasp diameter of 1/2" minimum. Key all padlocks alike. Provide two (2) keys for each padlock and turn over at the completion of testing and acceptance, with all keys identified.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Switch assemblies shall be installed in accordance with the manufacturer's instructions, the Contract Drawings, the latest edition of ANSI/IEEE Std. C37.35, and this specification.

- B. Units shall be equipped with removable lifting angles, eye-bolts or brackets for crane hooks or slings to be used for installation. Removable fittings shall not compromise the NEMA rating of the enclosure.
- C. Preparation for shipment shall be in accordance with the manufacturer's standard practices.
- D. Field install switches on the OCS structures as shown on the standard drawings and specified herein. Install field mounted switches in accordance with the shop drawings. Provide brackets, bolts and support items as required, in accordance with the disconnect switch manufacturer. Coordinate these installations with the design of the disconnect switch supporting hardware, feeder wire installation, and routing, and ensure that the designs are fully integrated with the installed attachments.
- E. Contractor shall take extreme care not to inflict damage to the insulators. Insulators shall be thoroughly cleaned with a nonabrasive cloth in accordance with the manufacturer's instructions.
- F. Ensure the structural adequacy of the OCS poles for supporting the mounted disconnect switches and accessories.
- G. Prior to energization of the OCS, verify correct operation of all disconnect switches installed.
- H. Any damage to the disconnect switch caused during storage, handling, installation, section testing, short circuit testing or commissioning of the system shall be the responsibility of the Contractor. Any disconnect switch deemed damaged shall be replaced by the Contractor at no additional cost to Caltrain.
- I. Provide all wiring as required. Provide conductor sizes, composition and insulation as indicated on the approved disconnect switch shop drawings. Provide and install all necessary additional hardware such as bushings, connectors, cable supports, grounding conductors, and all basic electrical materials needed for the installation of the equipment and accessories.
- J. Contractor shall provide all provisions, leveling shims or other incidental components to ensure all disconnect switches operate as intended by the manufacturer.
- K. The operating mechanism of the pole-mounted switches shall be attached to the poles and positioned so that the handles do not intrude into the track clearance envelope. In general, the operating handle shall move away from or parallel to the track. In addition, the switch must be installed in a position that a person operating the switch will not be in danger from passing vehicles. If doubt exists about which way to face a disconnect switch, obtain clarification. The operating handle shall be installed at a height that will allow the switch to be operated easily by a person standing on the ground. All switches shall be adjusted after installation in order to provide proper mating of the blades and easy alignment and operation. Either a working platform, built-up embankment with safety railing or leveled grade shall be provided at each disconnect switch location for Caltrain personnel access.
- L. Operating linkages shall be adjusted as necessary for smooth switch operation. Switch blade contacts at the jaw end of switches shall be visually checked for proper contact with spring fingers and proper blade position when the switches are fully closed.

3.02 INSPECTION

- A. Perform the following inspections:
 - 1. Proper blade position and wipe of blade contacts and stationary spring fingers during switch closing.
 - 2. Proper positioning of auxiliary position-indicating switches and linkage, if provided.
 - 3. Proper operation of position-indicating lights for motor-operated switches on the panel located in the relay and control enclosure.
 - 4. Proper indication of switch position on the operating pipe above the switch operator.
 - 5. Proper operation of motor limit switches.
 - 6. Visual inspection of insulator stacks for cracks or chipped areas.
 - 7. Check for overall disconnect switch levelness and adjust accordingly.

- B. Prior to energizing, perform and document the following tests for each disconnect switch:
 - 1. Confirm that nameplate information agrees with one-line diagrams and nameplate drawings.
 - 2. Inspect complete assembly for damage and missing parts.
 - 3. Visually inspect for cleanliness, chips, cracks, or other apparent damage to bushings.
 - 4. Visually verify that assembly is anchored to foundation adequately.
 - 5. Visually confirm equipment grounding.
 - 6. Visually confirm that control wiring is installed and terminated in the control cabinet.
 - 7. Visually confirm that no control wiring interferes with the internal moving mechanism.
 - 8. Verify torque of high-voltage terminal connections with a torque wrench.
 - 9. Verify that shipping blocks, plates, or straps have been removed.
 - 10. Check condensation heaters for proper operation if supplied.
 - 11. Confirm that control fuses/breakers are in place in accordance with equipment drawings.
 - 12. Measure control voltages.

13. Perform manufacturer's recommended inspections and tests, including control circuit checkout and test.
 14. Decouple switch from motor operator and check that motor turns in proper direction.
 15. Operate switch with control power. Check for smooth operation, full open and close. Check whether switch poles operate together.
 16. Check that internal and structure auxiliary switches are adjusted for proper operation/contact.
- C. After all connections and adjustments have been performed, test the switches for contact resistance. The minimum acceptable contact resistance shall be as specified by the manufacturer.

END OF SECTION

SECTION 34 30 79

OCS UNINSULATED CONDUCTORS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. This Section covers the design, manufacture, testing, supply, and installation of uninsulated conductors for the Overhead Contact System (OCS), as shown on the Caltrain Standard Drawings and specified herein. This work shall include the following conductors and cables:
1. Messenger Wire
 2. Contact Wire
 3. Along-Track Auto Transformer Feeder Wire
 4. Static Wire
 5. Jumper Wire
 6. Mid-Point Anchor Tie Wire
 7. Hanger Wire (also referred to as Dropper Wire)
 8. Cantilever "Nose" Dropper Wire
 9. Electrical Connection Wire
- B. The Contractor shall supply and install all applicable bare conductors and wires for the 25 kV AC Overhead Contact System in accordance with the requirements specified.

1.02 QUALITY CONTROL

- A. The Contractor shall perform the Work included in this Section in strict accordance with Section 01 43 00, Quality Control and Assurance.
- B. The Conductor Supplier shall perform the following
1. Material qualification testing and certification for acceptance of materials, components and assemblies.
 2. Job control testing of in-progress work being performed in shops, factories and on site.
 3. On-site inspection of specified work elements.

1.03 REFERENCES

- A. Codes and Standards: Pertinent provisions of the following listed standards shall apply:

1. American Society for Testing and Materials (ASTM)
 - a. B1-13, Specification for Hard-Drawn Copper Wire.
 - b. B3, Specification for Soft or Annealed Copper Wire.
 - c. B8-23, Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
 - d. B47, Specification for Copper Trolley Wire.
 - e. B173-17R24, Specification for Rope-Lay-Stranded Copper Conductors Having Concentric-Stranded Members, for Electrical Conductors.
 - f. B193, Standard Test Method for Resistivity of Electrical Conductor Materials.
 - g. B229, Specification for Concentric-Lay-Stranded Copper and Copper-Clad Steel Composite Conductors.
 - h. B231, Specification for Concentric Lay-Stranded Aluminum 1350 Conductors.
 - i. B232, Specification for Concentric Lay-Stranded Aluminum Conductors, Coated-Steel Reinforced (ACSR).
 - j. B258, Specification for Standard Nominal Diameters and Cross-Sectional Areas of AWG Sizes of Solid Round Wires Used as Electrical Conductors.
 - k. B549, Specification for Concentric-Lay-Stranded Aluminum Conductors, Aluminum-Clad Steel Reinforced for Use in Overhead Electrical Conductors.
2. European Standard (EN)
 - a. 50149, Railway applications. Fixed installations. Electric traction. Copper and copper alloy grooved contact wires.
3. DIN
 - a. 48201-2, Bronze Stranded Conductors.

1.04 SUBMITTALS

- A. Refer to Special Provisions Section 01 33 00, Submittal Procedures for review process.
- B. The Contractor shall submit Shop Drawings and technical data to Caltrain for review and approval prior to cable and wire manufacture. Included as a minimum shall be:
 1. Physical Characteristics and Parameters
 - a. Size

- b. Type
 - c. Material
 - d. Number of and diameter of individual wires
 - e. Overall diameter
 - f. Cross section area
 - g. Weight per foot
 - h. Rated breaking load
 - i. Modulus of Elasticity
 - j. Coefficient of Thermal Expansion
2. Electrical Characteristics
- a. Maximum rated ampacity and temperature for each size
 - b. Resistance per unit length
- C. The Contractor shall provide (3) 6 inch wire samples of all conductors proposed on this project for review and approval by Caltrain. Caltrain will distribute the wire samples to their respected engineering, operations and project offices.
- D. The conductor manufacturer shall provide certifications verifying that the conductors have been manufactured, inspected and tested in accordance with applicable portions of the referenced standards and the Caltrain standard drawings for which Caltrain has issued an approval.
- E. The Contractor shall provide certified copies of manufacturer's test reports for the specific conductors furnished, which shall include but not be limited to the following information:
- 1. Initial and Final Modulus of Elasticity (E)
 - 2. Coefficient of Thermal Expansion (CTE)
 - 3. Yield stress
 - 4. Hardness values

1.05 DELIVERY, STORAGE AND HANDLING

- A. Ensure that all materials furnished are suitably packaged and protected against damage during delivery and transportation.
- B. Store all products in accordance with the manufacturer's instructions to ensure that all material is protected from damage and exposure.

- C. Handle and otherwise use the wire and cable in accordance with the manufacturer's instructions, so as to ensure that the products are not damaged or misused prior to or during installation.
- D. All repairs and replacements of damaged cables shall be in accordance with the manufacturer's instructions. Any damage to the wire and cable prior to delivery shall be the cable supplier's responsibility.

1.06 WARRANTY

- A. The conductors shall have a minimum in-service life expectancy of 40 years under operating conditions with the exception of contact wire which is dependent upon the number of pantograph passes. Therefore, the normal wear of the contact wire is an acceptable reason for its replacement prior to 40 years.
- B. The conductors shall be unconditionally guaranteed by the manufacturer and/or supplier to be free from defects for a period not less than 2 years after acceptance by Caltrain.

PART 2 - PRODUCTS

2.01 MATERIAL

- A. Conductor materials shall be of a composition, quality, and purity, such that the finished product shall have the properties and characteristics described in this Section and on the Caltrain standard drawings. All conductors shall be of uniform size and shape.
- B. The bare conductor particulars shall be in accordance with the parameters indicated on the Caltrain standard drawings.
- C. Materials furnished shall be standard products of manufacturers regularly engaged in the production of the same materials specified.

2.02 BARE CONDUCTOR

- A. The work specified in this Article includes furnishing the main OCS conductors such as messenger wire, contact wire, jumpers, feeder wires, shunt wire, static wires, hanger wire, electrical connection wire, and cantilever dropper wires as shown on the Caltrain Standard Drawings, detail design and specified herein.
- B. All material shall be of such composition, quality that the finished product will have the properties and characteristics described in this specification and on Caltrain Standard Drawings.
 - 1. Contact Wire: Grooved hard drawn copper AC 107 Cu-Ag conforming to EN 50149 and the following requirements:
 - a. Diameter: 0.484 in (12.3 mm)
 - b. Shape: AC 107
 - c. Material: Cu-Ag 01

- d. Minimum breaking load: 8419 lbs (37.45 kN)
- 2. Messenger Wire: Stranded Bronze Bz II 70/19 bare conforming to DIN 48201 and the following requirements:
 - a. Overall Diameter: 0.413 in (10.5 mm)
 - b. Nominal Cross Sectional: 70 mm² Calculated: 0.1 in (65.81 mm²)
 - c. Strand Wires: 19
 - d. Material: Bz II
 - e. Minimum breaking load: 8687 lbs (38.64 kN)
- 3. Autotransformer (AT) Feeder Wire: Aluminum conductor, steel reinforced (ACSR) "Eagle" 556.5 KCMIL conforming to ASTM B232 and the following requirements:
 - a. Overall Diameter: 0.953 in
 - b. Material: Aluminum / Steel
 - c. Wires: Stranding - 30/7 (Aluminum/Steel)
Diameter – 0.1362 in / 0.1362 in (Aluminum/Steel)
 - d. Minimum breaking load: 27800 lbs (123.66kN)
- 4. Static Wire: Aluminum conductor, steel reinforced (ACSR) "Penguin" 4/0 AWG conforming to ASTM B232 and the following requirements:
 - a. Overall Diameter: 0.563 in
 - b. Material: Aluminum / Steel
 - c. Wires: Stranding - 6/1 (Aluminum/Steel)
Diameter – 0.1878 in / 0.1878 in (Aluminum/Steel)
 - d. Minimum breaking load: 8350 lbs
- 5. Gantry to Gantry feeder wire shown on Caltrain standard drawings all aluminum conductor (AAC) "Nasturtium" 715.5 kcmil conforming to ASTM B231 and the following requirements:
 - a. Overall Diameter: 0.975 in
 - b. Material: Aluminum
 - c. Wires: Stranding – No. of Wires 61
 - d. Minimum breaking Load: 13100 lb

6. Shunt Wire: Aluminum conductor, steel reinforced (ACSR) "Dorking" 190.8 KCMIL conforming to ASTM B232 and the following requirements:
 - a. Overall Diameter: 0.63 in (16.0 mm)
 - b. Nominal Cross Sectional: 0.237 in² (152.81 mm²)
 - c. Material: Aluminum / Steel
 - d. Wires: Stranding - 12/7 (Aluminum/Steel)
Diameter – 0.1261 in / 0.1261 in (3.2 mm / 3.2 mm)
(Aluminum/Steel)
 - e. Minimum breaking load: 18700 lbs (83.21 kN)
7. For additional requirements for hanger, cantilever droppers, electrical connection wire, and jumper wires refer to OCS Basic Design Assemblies Drawing SD-W6001.

2.03 PERFORMANCE

- A. The physical, mechanical and electrical properties of the conductors shall conform to the requirements of the Caltrain Standard Drawings and the pertinent provisions of all Standards referenced in this Section.
- B. Joins shall be permitted in drawing stock or intermediate rod stock as indicated in EN 50149, except no joins shall be made in completed wire.
- C. Wire manufacturer shall preform conformity verifications as indicated in EN 50149 during production of messenger and contact wires.

2.04 INSPECTION AND TESTING

- A. Caltrain reserves the right to witness the manufacture, testing and packing of all conductors. The conductor/cable manufacturer shall notify the Contractor not less than 20 days in advance of manufacturing and testing operations.
- B. All conductors shall be subject to factory quality control tests as required in the applicable Standards. Tests shall be performed on each reel prior to shipment in addition to other specified submittals; certified copy of the test report for each reel shall be submitted prior to shipment. A copy of the test report shall be packed with each reel.

2.05 PACKAGING AND MARKING

- A. All conductors shall be shipped on steel reels (unless otherwise approved by Caltrain) suitable for the weight of the conductors shall be protected from damage. The diameter of the reel shall be subject to Caltrain's approval and shall be sufficiently large to eliminate difficulty with wave or kinks when the conductor is strung. The grooved contact wire shall be wound on the reel in such manner that the vertical axis of cross section shall be vertical to the axis of the reel (i.e., the contact wire groove shall be on top to match its final installation orientation). If the

Contractor needs a different wire orientation for installation, then submit a Request for Information to Caltrain for review and approval.

- B. Each reel shall consist of one continuous conductor, and shall have the required length of conductor so that no field (external) splices are required in the tension sections as installed. The Contractor shall retain all remaining wire footages marked on each reel and shall be made available to Caltrain Operations as either scrap value or spares.
- C. Each reel shall have a strong, weatherproof tag or marker securely fastened to it, showing the size and type of conductor as well as the ASTM designation, name and mark of the manufacturer, total reel length and weight and manufacturer's special instructions.
- D. Factory splices in contact wire stock shall be marked with paint or dye prior to wire drawing. The marks shall be readily distinguishable after the wire drawing process.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Conductor installation shall be in accordance with Section 34 30 85, OCS Installation.
- B. Installation of cables shall be as shown on the OCS drawings. Ends of stranded wires shall be enclosed inside termination crimp connectors or otherwise secured to prohibit exposed frayed ends.

END OF SECTION

SECTION 34 30 80

OCS INSULATED CONDUCTORS AND CABLES

PART 1 - GENERAL

1.01 SCOPE

- A. This Section specifies the furnishing, installation, and testing of insulated conductors, cables, terminations, and associated materials for the 46 kV EPR 100% insulation level autotransformer (AT) feeder cables and surge arrester grounding cables, as shown on the Contract Drawings and specified herein.
- B. Cables covered by this specification are intended for use on an alternating current, 1-phase, 60-Hertz distribution system operating at 27.5 kV, and subjected to such additional strains of potential as may occur on the account of switching and operation of an overhead and/or underground distribution system.

1.02 REFERENCES

- A. All the cables furnished under this Section shall be in accordance with the latest applicable standards of the IEEE, ANSI, NFPA, NEMA, ICEA, AEIC, and UL with regard to material, design, construction, and testing. The standards applicable shall include, but not be limited to, the following:
 - 1. Association of Edison Illuminating Companies (AEIC):
 - a. CS8, Specification for Extruded Dielectric Shielded Power Cables Rated 5 through 46 kV.
 - 2. American Society for Testing and Materials (ASTM):
 - a. B1, Specification for Hard-Drawn Copper Wire.
 - b. B2, Specification for Medium-Hard-Drawn Copper Wire.
 - c. B3, Specification for Soft or Annealed Copper Wire.
 - d. B8, Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
 - e. B33, Specification for Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes.
 - f. B189, Specification for Lead-Coated and Lead-Alloy-Coated Soft Copper Wire for Electrical Purposes.
 - g. B496, Specification for Compact Round Concentric-Lay-Stranded Copper Conductors.
 - h. D3005, Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape.

- i. D4388, Standard Specification for Nonmetallic Semi-Conducting and Electrically Insulating Rubber Tapes
3. Institute of Electrical and Electronics Engineers (IEEE):
 - a. 48, Standard Test Procedures and Requirements for High-voltage Alternating Current Cable Terminators.
 - b. 82, IEEE Standard Test Procedure for Impulse Voltage tests on insulated Conductors.
 - c. 400, IEEE Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems.
 - d. 404, Standard for Cable Joints for Use with Extruded Dielectric Cable Rated 5,000 Volts through 46,000 Volts.
 - e. 532, IEEE Guide for Selecting and Testing Jackets for Underground Cables.
 - f. 837, Standard for Qualifying Permanent Connections Used in Substation Grounding.
 - g. 1210, Standard Tests for Determining Compatibility of Cable-Pulling Lubricants with Wire and Cable.
 - h. 1202, Flame Testing of Cables for Use in Cable Tray in Industrial and Commercial Occupancies.
 - i. 1235, IEEE Guide for the Properties of Identifiable Jackets for Underground Power Cables and Ducts.
4. National Electrical Manufacturers Association (NEMA):
 - a. WC 26, Bi-national Wire and Cable Packaging Standard.
 - b. WC 70, Standard for Nonshielded Power Cables Rated 2,000 Volts or Less for the Distribution of Electrical Energy.
 - c. WC 71, Standard for Nonshielded Cables Rated 2,001-5,000 Volts for Use in the Distribution of Electrical Energy.
 - d. WC 74, 5-46 kV Shielded Power Cable for Use in the Transmission & Distribution of Electric Energy.
5. National Fire Protection Association (NFPA):
 - a. 70, National Electrical Code (NEC)
6. Underwriters Laboratories (UL):
 - a. 44, Thermoset-Insulated Wires and Cables.

- b. 83, Thermoplastic Insulated Wires and Cables.
- c. 510, Insulating Tape.
- d. 1072, Medium-Voltage (Type MV) Solid-Dielectric Cables.
- e. 1581, Reference Standards for Electrical Wires, Cables and Flexible Cords.

1.03 QUALITY ASSURANCE

- A. Cable Manufacturers' Qualification: Not less than fifteen (15) years of demonstrable experience in the production of the specified products.
- B. Workmanship shall conform to the best modern practices in the manufacturing of a rugged, durable, and safe product for use in a public transportation system. Materials used shall be new and of the highest commercial grade as specified.
- C. The Insulated Cable shall be manufactured and tested under the control of a Quality Assurance system that conforms to the requirements of ISO 9000.
- D. The Quality Assurance system shall demonstrate conformance to the above criteria by having passed yearly quality audits conducted by outside independent organizations.
- E. Regulatory Agency Approvals: Comply with all applicable federal, state, and local laws, regulations, and codes, including those referenced herein.
- F. Furnish and install medium voltage power cables having a performance record demonstrating a minimum of 20 years' successful operating experience in utility and industrial power cable applications.

1.04 SUBMITTALS

- A. Refer to Special Provisions Section 01 33 00, Submittal Procedures for review process.
- B. The Contractor shall submit the following for review and approval of Caltrain at various stages of planning, manufacturing, and installation of cable and wire as requested:
 - 1. Descriptive literature, catalog data, and other pertinent information for cable sufficient to clearly demonstrate compliance with the Contract Documents. Product shall consist of manufacturer's standard catalog cuts, descriptive literature and diagrams, in 8½ X 11-inch format, and in sufficient detail so as to clearly indicate compliance with all specified requirements and standards. Submit catalog cuts for the following as a minimum:
 - a. Wires and cables for each type and size.
 - b. Conductor stranding

- c. Conductor material
- d. Conductor coating
- e. Insulation material
- f. Insulation thickness (mils)
- g. Shielding: Conductor (mils), Insulation (non metallic) (mils), Insulation (metallic) (mils)
- h. Maximum Copper Temperature: Continuous (°C), Emergency (°C), Short Circuit (°C)
- i. Minimum installation temperature (°C)
- j. Jacket material (°C)
- k. Jacket thickness (nominal) (mils)
- l. Physical Requirements Insulation/Jacket: Tensile strength (psi), Elongation at rupture (Set) (%)
- m. Aging Requirements: Insulation/Jacket
 - 1. After air oven test (indicate condition): Tensile strength, change in unaged value (%), Elongation at rupture, change in unaged value (%)
- n. Accelerated Water Absorption:
 - 1. Electrical method increase in capacitance: 1 to 14 days (%), 7 to 14 days (%)
 - 2. Gravimetric method water absorption (mg/in.)
- o. Electrical Requirements (Insulation): AC Voltage Test [kV/min.], DC Voltage Test [kV/min.], Insulation Resistance (min.) (megohms)
- p. Cable outside diameter (nominal) (inches)
- q. Allowable minimum bending radius (inches)
- r. Allowable pulling tension (lbs)
- s. Allowable sidewall pressure (psi)
- t. Reel Data: Diameter (inches), Width (inches), Drum diameter (inches), Tare weight (lbs), Arbor diameter (inches)

- u. Ampacities: Cable in ducts, one or two cables per duct per the duct bank drawing sections, earth temperature 20°C, RHO = 90, conductor temperature 90°C.
 - v. Electrical Characteristics (indicate conditions): Resistance (ohms/1000 ft.), Reactance (inductive) (ohms/1000 ft.), Impedance (ohms/1000 ft.)
 - w. Cable weight (lbs/1000 ft.)
2. As-built lengths of all cable installed.
 3. Manufacturer's Certification: Manufacturer shall submit signed certification confirming that they comply with the qualifications requirements and shall provide evidence of experience upon request.
 4. Product Certification: Signed by manufacturer certifying that products comply with the specified specification requirements.
 5. Report on Field Tests: Certified copies of field tests.
 6. (3) 6-inch-long samples of the final assembled cables for First Article Inspection prior to release.
 7. Submit certified shop test reports for wires and cables.
 8. Submit field test results for wires and cables, including megger readings with the method used.
 9. Installation and test instructions.
 10. Recommended pulling lubricants, compatible with the jacket and semiconducting shield materials.
 11. Recommended termination materials and procedures.
 12. Where required for interpretation of results. Authorization to ship will not in any way relieve the Manufacturer of this responsibility under this Contract.

PART 2 - PRODUCTS

2.01 GENERAL

- A. The cable shall be suitable for use in wet and dry locations in underground duct systems and aerial applications. The cable shall be rated no less than 90°C for normal operation, 130°C for emergency overload condition and 250°C for short circuit conditions.
- B. Emergency overload operation may occur for periods up to 100 hours per year and with as many as five (5) such 100-hour periods within the lifetime of the cable.

- C. Water-based, gel-type, high-performance cable-pulling lubricants shall be utilized in accordance with cable manufacturer recommendations.

2.02 INSULATED AUTOTRANSFORMER (AT) FEEDER CABLE

A. Electrical Ratings:

- 1. Single-conductor cable for the 27.5 kV nominal overhead contact system cables shall be rated for no less than 46 kV class line-to-line voltage rating basis described in NEMA WC 74.

B. Conductor:

- 1. Copper conductor, annealed, uncoated and Class B stranded, per ASTM B-8 for compressed round stranded, and ASTM B496 for compact round stranding.
- 2. The conductor sizes shall be 750 kCMIL for aerial AT feeder cable.
- 3. For portions of AT feeder cable installed in a ductbank, the contractor may utilize 1250 kCMIL, 46 kV cable per traction power specification section 34 31 86.

C. Conductor Screen:

- 1. The strands shall be completely shielded with a layer of semi-conducting extruded ethylene propylene rubber material compatible with the insulation. The compound shall have a maximum volume resistivity of 1000 ohm-meters at 105°C and a minimum elongation of 100 percent after an air oven test at 136° C for 168 hours. The strand shielding shall be in intimate contact with the strands and shall be completely free-stripping from the strands.

D. Insulation:

- 1. The insulation for 750 kCMIL and 1250 kCMIL cables shall consist of thermosetting Ethylene Propylene Rubber (EPR) which will meet the requirements of the referenced AEIC and NEMA specifications with the additional requirements listed below. The ethylene content of the elastomer used in the insulation compound shall not exceed 72 percent by weight nor shall the insulation compound contain any polyethylene. The insulation shall be compounded and extruded into a closed system to insure maximum cleanliness.
- 2. The insulation shall be circular in cross-section, and so centered that the minimum wall thickness shall be not less than 90 percent of the average thickness specified.
- 3. 46 kV class cables: Insulation thickness shall be in accordance with NEMA WC 74 Table 4-1 for a 100 percent insulation level (between 430 and 495 mils).

E. Insulation Screen:

1. The insulation shall be completely shielded with a layer of extruded semi-conducting ethylene propylene rubber compound. The compound shall have a maximum volume resistivity of 500 ohmmeters at 90°C and a minimum elongation of 100 percent after an air oven test at 136° C for 168 hours. It shall be in intimate contact with the insulation and shall be stripped with four to twenty-four pounds of tension per ½-inch wide strips at room temperature. The legend "SEMI-CONDUCTING SHIELDING, REMOVE BEFORE SPLICING OR TERMINATING" shall be printed in white indelible non-conducting ink along its entire surface.

F. Metallic Shield:

1. The insulation screen shall be shielded with a 5-mil tin-coated copper tape helically applied with a minimum overlap of not less than 20 percent. A longitudinal corrugated copper shield of equal or higher thickness will also be acceptable.
2. A sufficient number of concentric neutral conductors shall be applied over the metallic tape so that the combined conductivity of the tape and wire shields shall be at least 33 percent of the conductivity of the phase conductor.
3. The concentric conductors shall be No. 14 or No. 12 AWG bare, uncoated copper. They shall be evenly spaced and helically applied over the copper tape with a lay of not more than 12 times the cable diameter measured over the concentric conductors.

G. Jacket:

1. Black extruded flame retardant, low-smoke/zero halogen (LS/ZH), thermoplastic, polyolefin (TPPO) jacket.
2. Jacket and jacket thickness shall be in accordance with NEMA WC 74 and AEIC CS8 for 46 kV class cables.

H. Messenger:

1. Messenger shall be ½ inch diameter, extra high strength seven strand galvanized wire. The messenger shall be lashed to the 46 kV cable with stainless steel binder tape.

I. Conductor Sizes:

1. 750 kCMIL Aerial Feeder Cable: as shown in the standard and design drawings.
2. 1250 kCMIL Ductbank Feeder Cable
 - a. Diameter: 2.213 in (56.21mm) O.D.
 - b. Nominal Cross Section: 0.98 in² (633mm²)
 - c. Material: Copper

- d. Strand Wires: 91
- e. Minimum breaking load: 56,280 lbf (250.3 kN)

2.03 SURGE ARRESTER GROUNDING CABLE

- A. Electrical Ratings:
 - 1. Surge arrester grounding cables shall be rated no less than 2.4 kV.
- B. 2.4 kV Rated Grounding Cable for Surge Arresters:
 - 1. The conductor shall be 4/0 AWG Class B compressed stranded bare copper per ASTM B3 and ASTM B8
 - 2. Conductor shield shall be Semi-conducting cross-linked copolymer.
 - 3. Insulation shall be Cross Linked Polyethylene (XLPE).
- C. Conductor Sizes:
 - 1. 4/0 AWG Grounding Cable for Surge Arresters
 - a. Diameter: 0.764 in (19.4mm) O.D.
 - b. Nominal Cross Section: 0.1659 in² (107mm²)
 - c. Material: Copper
 - d. Strand Wires: 19
 - e. Minimum breaking load: 1,693 lbf (7.5 kN)

2.04 CABLE IDENTIFICATION AND LABELING

- A. The following information shall be printed on jacket, using contrasting indelible color ink, at intervals per NEMA WC 70, WC 71 and WC 74 as applicable:
 - 1. The words: "Property of Caltrain"
 - 2. Manufacturer's name and plant, and year of manufacture
 - 3. Conductor size and material
 - 4. Voltage rating
 - 5. Insulation type and thickness (mils)
 - 6. Jacket type and thickness (mils)
 - 7. Percent insulation level
 - 8. UL designations (where applicable)

9. Other appropriate conductor information

2.05 TERMINATING AND ARC-PROOFING MATERIALS

- A. Terminating shall be as specified in this Section. Details of terminating shall be as shown on the Plans or in accordance with manufacturer's recommendations. Any terminating methods other than those specified below, for which the components are in accordance with the requirements of this Section, shall be submitted for approval.
- B. Splices shall not be permitted.
- C. Cable termination fittings and lugs shall be compatible with the feeder cable and the switchgear, disconnect switch, or impedance bond to which the terminations are being made.
- D. Connectors: Subject to compliance with requirements of this Section, provide connectors of the following types:
 1. Solder-less, uninsulated, high-conductivity, corrosion-resistant, compression connectors conforming to UL 467 and IEEE 837.
 2. Insulated, indenter-type compression butt connectors.
 3. Insulated, integral self-locking flexible shell, expandable spring connectors.
 4. Uninsulated, indenter-type compression pigtail connectors.
 5. Welded-type connectors.
- E. Terminals: Subject to compliance with requirements of this Section, provide terminals of the following types:
 1. Solder-less, uninsulated, high-conductivity, corrosion-resistant, compression terminals conforming to UL 467 and IEEE 837.
 2. Insulated, compression terminals.
 3. Solder-less, high-conductivity, corrosion-resistant, hex screw-type, bolted terminals.
 4. Welded-type terminals.
 5. Medium-Voltage Cable Terminators:
 - a. Shall consist of a factory-engineered kit and copper connector specifically designed for the terminating of the associated shielded cable in an outdoor location. Terminator shall be rated 46 kV, with an ac withstand one minute-voltage of 120 kV. Kit shall meet IEEE 48, Class 1 requirements, and be capable of passing the appropriate test sequence of IEEE 404. Kits shall

provide for the grounding of the cable shield without the use of special construction.

- b. Shall consist of heat-shrinkable stress control and outer non-tracking insulation tubing and outer skirts. Terminals shall be all copper, of high-conductivity, corrosion-resistant type, conforming to UL 467. Terminating kits shall be Raychem, or approved equal, and connectors shall be Burndy, or approved equal.
- F. Shrinkable Tubing: Subject to compliance with requirements of this Section, provide shrinkable tubing of the following types:
1. Either irradiated modified polyvinyl chloride or irradiated modified polyolefin heat shrinkable tubing;
 2. Cold shrinkable tubing.
- G. Tapes and Sealers:
1. Vinyl Tapes: Flame retardant, cold and weather-resistant, 3/4-inch or 1-1/2-inches wide, as required, and conforming to UL 510 and ASTM D 3005.
 - a. For interior, dry locations, provide seven mils, conforming to ASTM D 3005 (Type 1); Scotch (3M) No. 33, or approved equal.
 - b. For exterior or damp and wet locations, provide 8.5 mils, conforming to ASTM D 3005 (Type II); Scotch (3M) No. 88, or approved equal.
 2. Rubber Tapes: Ethylene propylene rubber based, 30 mil splicing tape, rated for 130°C operation; 3/4-inch and wider (1, 1-1/2, 2-inches) as shown on the Plans or approved by Caltrain, conforming to ASTM D 1373 and FS HH-I-553 (Grade A); Scotch (3M) No. 130°C, or approved equal.
 3. Insulating Putty: Rubber based 125 mil, 130°C rated, anti-tracking, self-fusing tape; one-inch wide; Scotch (3M) No. 70 or approved equal.
 4. Silicone Rubber Tapes: Inorganic silicone rubber, 12 mil, 130°C rated, anti-tracking, self-fusing tape; one-inch wide; Scotch (3M) No. 70 or approved equal.
 5. Sealer: Liquid-applied, fast-drying sealant; Scotch (3M) Scotchkote, or approved equal.

PART 3 - EXECUTION

3.01 CABLE SHIPPING, STORAGE, AND HANDLING

- A. Cable shall be packaged in accordance with NEMA WC 26 and the requirements stated herein. Protective reel coverings shall be Level 3 or greater in accordance with NEMA WC 26.

- B. Insulated Cable for this design package shall be furnished in accordance with the Plans and with the following requirements. The Contractor is responsible for cable shipment, storage, and security.
1. All traction power cable for this contract shall be shipped freight on board (FOB) site to the Contractor's designated storage area - unless cable is part or spare or surplus materials. Cable shall be shipped on reels with protective covering, including wooden lags, commensurate with the weight of the loaded reel.
 2. A watertight seal shall be applied to each end of the cable to prevent moisture ingress during shipment or outdoor storage. The Contractor shall provide factory-applied caps to wire and cable sizes No. 4/0 AWG and larger unless otherwise shown on the Plans. End seals shall be heat-shrink, irradiated, modified polyolefin, and shall be sized for individual wires and cables.
 3. A durable, weatherproof label shall be securely attached to the outside of both flanges of each reel. Each label shall indicate the following:
 - a. Purchase order number
 - b. Name and address of manufacturer
 - c. Reel number
 - d. Total length of cable on reel
 - e. Description of cable
 - f. Tare and total weight of reel and rolling direction
- C. The Contractor shall ensure that single conductor wire or cable sizes No. 4/0 AWG and larger that are to be installed in the same raceway are paralleled by the cable manufacturer before shipment. Cable assembly overall diameter shall be kept to a minimum.

3.02 INSTALLATION REQUIREMENTS

- A. Keep wires and cable dry at all times. Cable ends shall be properly sealed before stringing cable. Cable ends shall not be left with insulation exposed after cutting unless splicing is to be performed immediately. Before terminating wires and cables, make a thorough inspection to determine that water has not entered the wires and cables or that the wires and cables are damaged.
- B. Strip all nails from the outside edges of reel heads before stringing of cable. Conveniently locate reels for stringing cable without excessive bending or possible injury to cable by abrasion. Reels shall be jacked to clear ground level or obstructions by at least six (6) inches before stringing of cable.
- C. Where the aerial insulated autotransformer feeder cable is installed in conduit, the messenger and messenger lashing shall be removed prior to installation.

- D. For additional Traction Power Underground and Ductbank installation requirements see Specification Section 34 31 23.

3.03 CABLE WARRANTY

- A. The Contractor shall replace any length of cable installed by the Contractor which fails during normal use within one year of installation, provided immediate written notice of such failure is given to the Contractor with all reasonable opportunity provided thereto to inspect such failure.
- B. The date of installation of the service shall be interpreted as the date on which operating voltage is first continuously applied to the completed cable installation.

3.04 INSPECTION AND TESTING

- A. Inspection: Caltrain reserves the right to witness the manufacture, testing, and packaging of all conductors. The Contractor shall notify Caltrain not less than ten (10) days in advance of manufacturing and testing operations.
- B. Testing: The standard dielectric-withstand tests shall be performed on each reel of cable prior to shipment. A certified copy of the test report for each reel of cable shall be furnished to Caltrain prior to shipment. A copy of the test report shall also be packed with each reel. Test requirements shall be in accordance with NEMA WC-70, WC-71 and WC-74 as applicable.
- C. Submit samples not less than (6) inches in length, with a copy of the notarized certified test reports of each type and size of wire and cable to be furnished for First Article Inspection prior to release.

3.05 SHOP TESTS

- A. For quantities as shown on the Plans, regular dielectric-withstand and insulation resistance in water tests for wires and cables shall be performed in accordance with the referenced standards.
- B. Flame tests for wires and cables shall be performed in accordance with vertical tray flame test of UL 1581 F. Cable sizes larger than 1/0 AWG shall meet the vertical tray flame test requirements of IEEE 1202.
- C. The test results shall be certified for each reel/coil/box of wire or cable.
- D. Factory inspection and witnessing of tests by Caltrain may be required for all wires and cables furnished under this Contract. Caltrain reserves the right to require additional testing, or to waive factory inspection or witnessing of tests. The Contractor shall notify Caltrain fourteen (14) days in advance of the scheduling of such factory tests.

3.06 FACTORY CABLE TESTS (FULL LENGTH)

- A. Tests conducted at the factory shall include, but not limited to, the following standard tests as per NEMA WC 70, WC 71 and WC 74, as applicable, for the entire completed cable:

1. Insulation Resistance Tests: These tests shall be performed in accordance with the requirements of the referenced standards. Each cable shall have an insulation resistance not less than that corresponding to the insulation resistance constant of at least 50,000 megaohms per 1,000 feet at 15.6°C.
2. Shield Resistance: shall be measured and recorded from end to end on the completed cable.
3. Corona Test: Each reel of completed shielded power cable shall comply with the maximum partial discharge in pico-coulombs. The partial discharge test shall be performed in accordance with the procedures of AEIC CS8 and CS9 and an X-Y recording graph will be furnished showing the corona test results.
4. Water Block Test: A water penetration production test for filled strand cable construction shall be performed on each master length of insulated conductor.
5. Flame Test: Flame Test shall be performed in accordance with the referenced standards.

3.07 FIELD TESTS

- A. Inspect wires and cables at terminations for physical damage and proper connection.
- B. Verify continuity of each circuit conductor.
- C. All feeder cables shall be Hi-pot tested to NETA and the test report shall be submitted for approval. Furnish Caltrain with a copy of the megger readings together with an outline of the method used. If, in the opinion of Caltrain, any reading is lower than that required by applicable codes, promptly replace the materials involved, at Contractor's expense, and retest.
- D. Cables shall be subjected to Acceptance Tests as specified below to ascertain that the dielectric strength of the cable insulation has not been impaired during installation, that the splices and terminations are properly made and to confirm the integrity of the cable system prior to energization. These shall include continuity tests and insulation resistance tests performed after the cable installation.
- E. Acceptance Tests: After installation of the entire length of cable, the Contractor shall perform the tests listed below on each cable in accordance with the Acceptance Testing Specifications of the National Electrical Testing Association (NETA). To preclude damage to equipment and devices, the tests shall be conducted before the cable is terminated at electrical equipment. If terminations have already been made, cables shall be disconnected from the equipment for testing and shall be reconnected after completion of tests.
 1. Dielectric Test:

- a. This test shall be performed to ensure that the cable insulation has not been impaired during installation.
2. Continuity Test:
 - a. This test shall be performed to prove the continuity of the conductor.
 3. Insulation Resistance Test:
 - a. This test shall be performed to determine the cable insulation resistance to ground.
 - b. Megger test voltage shall be applied between the conductor and ground and shall be held until the reading reaches a constant value for five (5) minutes. Insulation resistance values obtained by the megger tests shall not be less than two megaohms at 1,000 V. Contractor shall bring to the attention of Caltrain the results of similar tests having unequal readings with the variations of twenty-five (25) percent or more.
 - c. For each test, the Contractor shall record the temperature, humidity and duration of the test.
- F. Defective Cables:
1. Cable conduits shall be sealed after testing and final connection of cables. Any cable installed under this Contract found defective during the testing shall be replaced with new cable at the expense of the Contractor.

END OF SECTION

SECTION 34 30 85

OCS INSTALLATION

PART 1 – GENERAL

1.01 SUMMARY

- A. This Section specifies the installation requirements for the Overhead Contact System (OCS), broadly defined as the conductors and related components forming the overhead power distribution system. The OCS includes the messenger and contact wires, ancillary pull-offs and backbone wires, hangers, feeder cables, jumpers, sectioning devices, cross spans and head spans, tensioning systems, and ground connections, along with their associated supports, hardware, equipment, and insulation.
- B. Coordinate the OCS installation with the staging and interface requirements as set forth in Section 34 30 03, OCS general and Interface Requirements. The contractor shall submit detailed plans for all proposed temporary anchorages, guying, electrical isolation and protection required to turn over discrete sections of the system to Caltrain for its use as required in Section 34 30 03, OCS General Requirements.
- C. Coordinate electrical and service outage requirements for connecting new adjacent sections of the OCS to those sections of OCS previously energized.

1.02 QUALITY CONTROL

- A. Perform the Work included in this Section in strict accordance with the requirements of Section 01 43 00, Quality Control and Assurance.

1.03 REFERENCES

- A. Most recent version of American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual for Railway Engineering, Chapter 33 Electrical Energy Utilization
- B. Most recent version of European Committee for Electrotechnical Standardization (CENELEC) Standards
 - 1. EN 50119, Railway Applications-Fixed Installations-Electric Traction Overhead Contact Lines
 - 2. EN 50122-1, Protective Provisions Against Electric Shock
 - 3. EN 50124-1, Insulation Coordination in Railway Applications
 - 4. EN 50149, Electric Traction: Copper and Copper Alloy Grooved Contact Wires
 - 5. EN 50317, Railway applications: Current collection systems - Requirements for and validation of measurements of the dynamic interaction between pantograph and overhead contact line

- C. California Code of Regulations (CCR) Title 8, Division 1, Chapter 4, Subchapter 5: Electrical Safety Orders
- D. Most recent California Public Utilities Commission (CPUC) General Orders (GOs)
 - 1. CPUC GO 26-D, Regulations Governing Clearances on Railroads and Street Railroads with Reference to Side and Overhead Structures, Parallel Tracks, Crossings of Public Roads, Highways, and Streets
 - 2. CPUC GO 95, Rules for Overhead Electric Line Construction
 - 3. CPUC GO 143-B, Safety Rules and Regulations Governing Light Rail Transit
 - 4. CPUC Resolution SED-2.

PART 2 – PRODUCTS

Not applicable.

PART 3 – EXECUTION

3.01 OCS INSTALLATION TOLERANCES

- A. Contact Wire Stagger
 - 1. Open Route ± 1 inch
 - 2. Bridge-Resilient Arms 0.5 inch
- B. Contact Wire Height
 - 1. Mainline installation tolerance -0 inch, + 1 inch
 - 2. Mainline vertical tolerance height -0 inch, + 1 inch
 - 3. Yard -0 inch, + 1 inch
 - 4. Bridge resilient arms -0 inch, + 0.5 inch
 - 5. Contact wire height through transitions shall follow maximum design gradient within the transition and half this value for two consecutive spans. Contact wire height difference between two consecutive spans, on flat levels shall not exceed half the maximum design gradient corresponding to the speed limit.
 - 6. Contact wire staggers shall be relative to track centerline.
- C. Messenger Wire/Contact Wire Offset ± 2 inch
- D. Hanger Location along track tolerances ± 3 inch
- E. Hanger Length ± .25 inch
- F. Hanger verticality ± 0.5 inch

- G. Cantilever Setting Tolerance (cross track) ± 3 inch

3.02 INSTALLATION OF OCS COMPONENTS

- A. Insulators, Hardware, and Connectors: Install in accordance with manufacturer's instructions.
- B. All OCS supporting devices including steady arms, messenger supports and cross-span or wire pull-off/backbone registration assemblies shall be installed as shown on the approved shop drawings and Contract Drawings.
- C. All connections, bolts, and nuts shall be properly torqued in accordance with the torques shown on the approved shop drawings, component drawings, and manufacturer's recommendations. Contractor shall not use impact wrenches or rattle guns as the means to finalize the installation of clamps and connectors. All OCS components shall be properly installed using torque wrenches set to the proper value per the manufacturer instructions. Alternative installation methods and procedures may be presented to Caltrain for approval.
- D. All items shall be inspected for form, function, fit, damaged coatings or bent/kinked members. Any piece found to be defective shall be rejected and a replacement shall be installed at the Contractor's expense.
- E. Cantilevers shall be installed as shown on the approved shop drawings. Take field measurements prior to cantilever fabrication, to determine the as-built dimension from centerline of track to face-of-pole at either contact wire height or messenger wire height. Due allowance shall be made, during cantilever fabrication, for dead load (static) deflection of the pole.
- F. For stability during stringing, the cantilevers shall be temporarily restrained to prevent collapse due to swinging; especially around curve track areas. The details of the temporary restraints shall be submitted for Caltrain's review and approval.
- G. Cotter pins and nuts on each cantilever shall be located on the same side of the structure at the side that has the maintainer facing oncoming traffic to assure uniformity along the line, ease of maintenance, and safety.
- H. Assemblies fitted with pins, cotters, bolts and nuts shall be oriented where possible in such a manner as to lock these components together by gravity if the pins or nuts should, for some reason, become detached under service conditions.
- I. Components employing a hinge or swivel shall be lubricated with grease before assembly of the rubbing surfaces, if so recommended by the OCS material suppliers. Grease product shall be subject to Caltrain's review and approval.
- J. All conductors shall be brushed and greased prior to the application of current carrying clamps and connectors. Aluminum to aluminum or aluminum to copper contact surfaces shall be coated with "Burndy" Penetrox A or Alnox compound or equal. Copper to copper contact surfaces shall be treated with "Burndy" Penetrox E compound or equal. Contractor shall verify with the clamp manufacturer torque values based on wet and dry applications.

- K. When aluminum to copper contact surfaces require to be in contact to prevent copper corrosion, add bi-metallic couplings and orientate products to be rain-washed on their exposed surfaces.
- L. The wire heights and staggers given on the Contract Drawings are related to the inclined centerline of track with superelevation on superelevated tracks, as shown on the Contract Drawings.
- M. All high-strength bolts or threaded rods shall be installed with the end of the bolt projecting at minimum two thread lengths beyond the outer face of the nut after tightening; however, the end of the bolt must never extend more than 1.5 inches beyond the nut or locknut. Threads of all bolts, nuts, and machine screws shall be torqued using a calibrated torque wrench in accordance with the manufacturer recommendations. Fittings, fasteners, or any other attachments that do not fit, are cracked, sustain galvanizing damage during installation, or are found to be defective in any way shall be rejected. The threaded portion of the bolt shall extend completely through the nut, developing full engagement and bolt strength. Any deviation from this requirement must be presented to Caltrain with a manufacturer certified letter and will be subject to approval.

3.03 INSTALLATION OF CANTILEVERS

- A. The types of cantilever and registration assemblies to be installed on each pole or support shall be as indicated on the OCS Layout and Material Allocation Drawings.
- B. The range of cantilever types available for installation shall permit erection of contact wires and messenger wires with a continuous range of system height values between minimum and maximum in the approved wiring layout plans or schedules.
- C. The type of cantilever to be installed at each location shall be selected based upon the site-specific pole loadings.
- D. The along-track offset of the cantilever on completion shall be in accordance with its distance from the midpoint anchor for the prevailing temperature.
- E. After installation of cantilevers and stringing of conductors, adjustment may be required to the stagger, heel setting, and contact wire height and cantilever inclination to be within the specified design tolerances.
- F. All clamps and connectors shall be installed in accordance with the manufacturer's instructions including torque applications for bolted type connectors. Caution must be taken not to cause galling of the stainless steel threaded bolts/connectors. Contractor shall replace all damaged connectors at no additional cost to Caltrain.
- G. Erect the cantilevers on each pole at the heights necessary to obtain the designed OCS heights.
- H. A suitable jig to allow workshop pre-assembly of the cantilevers, to specific dimensions, shall be developed. Using the jig together with wire heights, staggers, and system heights given in the layout plans and the actual pole face to track centerline site dimension, measured at contact wire level, manufacture the cantilever for each location.

- I. Prepare diagrams or charts indicating the actual cantilever tube lengths and diameters for each cantilever installed throughout the Project. The documents, in addition to the tube lengths, shall also indicate the cantilever location, track, and OCS registered and supported. Submit the structural erection diagram (SED) documents to Caltrain as part of the as-built package.
- J. Cotter pins and nuts on each cantilever shall be located on the side of the structure facing normal direction of traffic. In addition, the assemblies fitted with these components shall be oriented, whenever possible, in a manner which will hold the components together by gravity should the pins or nuts become detached during service conditions.
- K. Components employing a hinge or swivel shall be greased with an approved grease before assembly of the rubbing surfaces, and cleaned of excess grease. Defects in the galvanizing of the completed cantilevers shall be repaired by the application of suitable zinc-rich, cold galvanizing repair paint, or approved equal.
- L. After installation of the cantilevers and stringing of the conductors, adjustments shall be made to the stagger, heel setting, contact and messenger wire heights, and alignment as necessary. The cantilever, for auto-tensioned simple catenary, shall be adjusted for along-track movement. The extent of this movement is based upon the temperature and the cantilever distance from the midpoint anchor, after weights are freed.
- M. Compression or wedge type connectors shall be installed according to the manufacturer's recommended orientation and instructions.

3.04 INSTALLATION OF BALANCE WEIGHT ANCHOR (BWA) AND MID-POINT ANCHOR (MPA)

- A. Install BWA assemblies as indicated on the design and Shop Drawings. All wire rope shall be non-rotational stainless steel.
- B. The MPA assembly for each wire run must be fully installed prior to the installation of the respective auto tensioning devices.
- C. Auto tensioning devices shall be installed at elevations and locations as indicated on the design and/or Shop Drawings.
- D. The type of balance weight assembly at each location shall be as indicated on the design Documents.
- E. A general chart, showing BWA assembly height tolerances, which refers to a reference levels for various wire temperatures and tension lengths shall be included on the design and/or shop drawings.
- F. Auto tensioning devices shall be free moving between conductor temperatures as shown on related design drawings. Cantilever brackets or other equipment shall not interfere with the balance weight stack full range of motion over all operating temperatures.
- G. Special care shall be taken during installation of auto tensioning devices to obtain correct wire temperature and travel clearance for the balance weight and pulley

assemblies. Preliminary prestressing of the OCS to remove creep shall be completed prior to finalization of the balance weight settings. Submit prestressing procedure for Caltrain approval. Prestressing is not required if cables installed at full tension using wire trains. Contractor shall adjust all balance weight assemblies before final commissioning of the system.

- H. Auto tensioning devices shall be suitably adjusted to provide the required weight and operational range as shown on the standard and design drawings.
- I. An approved lubricating grease shall be applied to hinges, guideways and guide rods.

3.05 INSTALLING HANGERS

- A. Prior to fabricating and installing OCS hangers, record the as-built OCS span lengths. Hanger lengths shall be calculated, fabricated and installed to suit the as-built span lengths, per the required tolerances mentioned within these specifications.
- B. Perform field adjustments of hangers, messenger and contact wire heights as necessary to maintain the OCS in compliance with the Caltrain standard drawings and contract documents.
- C. Wire stagger, wire height, and heel settings shall be in accordance with the Caltrain standard system design drawings.
- D. Space hangers (in the along-track direction) per the required tolerances mentioned within these specifications.
- E. Any damage to the interfacing components during installation shall be replaced or repaired.
- F. No part of the hanger, especially the loop paddle, shall fall below the contact wire.
- G. All hangers shall be finalized vertically plumb before final commissioning of the system.

3.06 STAINLESS STEEL WIRE AND WIRE ROPE

- A. Stainless steel wire and wire rope shall be used as shown on the Caltrain Standard Drawings.
- B. The cut ends of stainless steel wire rope shall be enclosed inside crimp sleeves or otherwise band with wire to secure all exposed ends.

3.07 INSTALLATION OF DOWN GUYS AND AERIAL HEAD GUYS

- A. Install down guys and aerial head guys before the OCS conductors are installed. Pulled taut, and secured in place with provisions for future adjustment as required to support the OCS structure in proper alignment after the OCS conductors are installed to their final configuration and tensions.

- B. Install down guy and aerial head guy terminations and attachments as recommended by the Manufacturer.
- C. Install guy guards as indicated on the approved shop drawings, or as deemed necessary in the field to protect the public and/or the Caltrain maintenance workers from any potential danger imposed by the guy wires.
- D. Make all final adjustments necessary to the down guys and aerial head guys to compensate for initial stretch to ensure the proper long-term support and alignment of the OCS wires.

3.08 INSTALLATION OF PULLOFF AND BACKBONE WIRES

- A. Pull-off and backbone assemblies shall be manufactured in accordance with the OCS wiring layout drawings. The actual site measurements shall be obtained and the pull-off assembly erected on the poles.
- B. After conductor stringing, the pull-off shall be adjusted to obtain the correct conductor heights, staggers, and heel settings. The loading on the assembly should be checked to ensure that the assembly is acceptable under all loading conditions, shall not sag, and will not infringe on the pantograph clearance envelope.
- C. All pull-offs and backbones shall contain insulation in addition to any inter-track insulation that may be required. Insulation shall be provided to allow for grounding of adjacent electrical sections with single points of insulation between grounded and live sections.
- D. Install backbone wires and pull-offs before the OCS wires are installed. Provide wires of the correct length and secured in place with provisions for future adjustment as required to register the OCS structure in the proper horizontal alignment after the OCS wires are installed to their final configuration and tensions.
- E. Install pull-off assemblies as indicated on the standard and design drawings to hold the OCS system in its correct horizontal alignment on curves prior to tensioning.
- F. Make all final adjustments necessary to the backbone wires to compensate for initial stretch to insure the proper long-term support and alignment of the OCS wires.
- G. No part of the pulloff assembly (single or multi-track) shall conflict with the static pantograph envelope.

3.09 INSTALLATION OF SECTION INSULATORS

- A. Install section insulators as indicated on the design drawings and shop drawings.
- B. All electrical connectors and clamps are to be prepared and protected externally and internally in accordance with the manufacturer's recommendations.
- C. The method of installation shall assure there is no damage to the OCS conductors. Repair or replace any kinked contact wire in accordance with the documents.

- D. Maintain and adjust all new section insulators to provide for smooth passage of the pantograph and uninterrupted current collection by the pantograph until such time the OCS is accepted.
- E. Contractor shall test all section insulators to verify proper operation under simulated operational conditions. Testing shall be performed using a mock pantograph system that applies a minimum uplift force of 22 lbs. to the contact wire.

3.10 STRINGING OF CONDUCTORS

- A. All conductors shall be installed in accordance with good railroad OCS practice and overhead line practice, and the manufacturers' recommendations. Conductor creep shall be considered in tensioning messenger and contact wires except if stringing is at full tension by a wire train. Prepare and submit procedures for this item.
- B. Conductor tensions, cantilever settings, and auto tensioning assemblies are temperature related. During stringing, actual conductor temperatures as measured by contact thermometers shall be used in conjunction with the stringing charts to ascertain the various stringing parameters. Laser or infrared temperature guns shall not be used to record conductor temperatures without specific prior approval by Caltrain.
- C. Messenger and contact wires shall not be spliced without specific prior approval by Caltrain. When required for construction, obtain Caltrain's approval and install full-tension wire splices.
- D. Splices in feeder and static wire conductors shall comply with the following conditions:
 - 1. In general, there shall not be more than one splice per conductor per mile.
 - 2. Splices shall be located at least 25 feet away from poles.
 - 3. Splices shall not be permitted at grade crossings and at underbridges.
- E. Care shall be taken to avoid kinks in the wires. Destranding (birdcaging) of stranded conductors shall be prevented. Kinks in the contact wire shall be avoided.
- F. The contact wire shall be free of twists from anchor clamp to anchor clamp.
- G. Termination fittings shall be oriented in accordance with the standard and design drawings.
- H. Prior to energization, conductors may be grounded during and after the stringing process as required or identified by Caltrain.
- I. All conductors subjected to short circuit testing shall be protected with armor rod or similar protective devices at points of contact with test connections. This protection shall be installed to prevent mechanical damage to the conductor strands that may result from high fault currents and electromagnetic forces during testing.

3.11 PRECAUTIONS IN HANDLING CONDUCTORS

- A. All conductors shall be handled in such a manner that they will not be scratched, cut, or nicked with tools or clamps.
- B. Conductors shall not lie upon, or be dragged across, sharp or rough surfaces (such as the track or ground).
- C. Conductors which are, or become, annealed shall be replaced without exception.
- D. Kinks or sharp bends shall not be put in the conductors.
- E. Conductors shall not be looped to form dead-ends of either a temporary nature or a permanent nature.
- F. Conductors shall not be wrapped around poles or other anchorages.
- G. Conductors shall not be marred with temporary wire or hook hangers.
- H. Only parallel jaw clamps shall be used in tensioning all conductors. The grooves of the clamps must be free from burrs, fins, or any roughness, and the ends of the grooves must be flared (bell-shaped).
- I. Vertical kinks in the contact wire shall be removed.
- J. Lateral kinks in the contact wire shall be removed if they affect the fit of any parts, or are judged as prejudicial to good current collection by Caltrain.

3.12 INSTALLATION OF OCS SUPPORTS ON BRIDGES

- A. Existing reinforcement bars and pre/post tensioning tendons must be located by appropriate devices prior to drilling for anchor bolts.
- B. Field drilling of bridge girder webs (concrete or steel) will not be permitted unless expressly permitted by the Bridge owner. A written copy of this permission will be provided to Caltrain prior to the commencement of any related work.
- C. Bridge support designs and methods of anchoring and installation shall be submitted for review and approval. At each location, the actual bridge to rail level dimension shall be measured and the steelwork for the support assembly manufactured to obtain the conductor design heights. After completion of the assembly installation together with the associated steelwork, the bridge arms shall be adjusted to obtain the conductor heights and staggers as shown on the layout plans.
- D. Sufficient adjustment of the assembly shall be left available to allow for possible future maintenance requirements. The contact support arm shall also be adjusted to ensure that the uplift, under normal pantograph pressure, does not exceed the value used in the pantograph clearance envelope.
- E. Each location shall also be carefully checked to ensure that the electrical clearances between live equipment and the structure are not infringed under any climatic or operating conditions.

- F. Contractor shall adjust the bridge supports if arc flash is present under live run testing to ensure proper pantograph operation. Final acceptance will be subject to approval by Caltrain.
- G. Attachments of OCS Supports to bridges shall only be at structure locations specified on the design documents.

3.13 IDENTIFICATION OF OCS STRUCTURES

- A. All OCS structures shall be clearly and permanently numbered, using the pole identification requirements shown on the design drawings.
- B. OCS supports under bridges, shall be assigned structural number in the same size and style as employed for poles.
- C. All temporary contractor construction markings shall be removed from the structures and supports with approved cleaners intended for the application. Cold galv. or spray paint shall not be used to cover such markings.

3.14 INSTALLATION OF JUMPERS

- A. Configurations of all types of jumpers shall be as shown on design drawings.
- B. Jumper wires shall have ends projecting not more than 1/2 inch through open clamps.
- C. In all cases, jumpers shall be installed so as to avoid conflicts with the pantographs, adjacent cantilevers, and hangers at all times.
- D. Each jumper end shall be cleaned with an accepted decontaminant immediately prior to making connections.
- E. Connectors shall be oriented as indicated and shall be installed in accordance with the manufacturer's recommendations.
- F. Conductor interfaces of all clamps for feeder terminations, equalizing jumpers and continuity jumpers shall be coated with conductive grease before installation and cleaned of excessive grease after installation.
- G. Any part of the jumper conductor shall not fall below the contact wire at any given time or environmental condition.

3.15 INSTALLATION OF INSULATORS

- A. All insulators shall be cleaned before installation. Only clean rags free from any abrasive material shall be used for cleaning insulators.
- B. Wire brushes shall not be used for cleaning any part of an insulator including the metal fittings.
- C. Porcelain insulators, if used, having broken or cracked sheds shall be rejected.

- D. In the completed OCS, all insulator assemblies shall be clean, bright, and free from nicks, chips, or other marks.
- E. Polymer insulators with damaged sheds shall be completely replaced at the Contractor's expense. Field repair of any kind will not be allowed.

3.16 FIELD TOUCH-UP

- A. Galvanized Metal Surfaces: Coat damaged surfaces to meet the finish of the original coating, with polystyrene organic rich compound containing not less than 91 percent by weight metallic zinc powder in dried form.
- B. Painted Metal Surfaces: Clean, treat, and coat damaged surfaces with required rust inhibiting undercoating and finish coat paint system in accordance with paint manufacturer's instructions.
- C. Fiberglass Reinforced Polyester Enclosures: Repair only minor damaged surface with materials and methods as recommended by manufacturer. Major damage will require complete component replacement.

3.17 FINAL ADJUSTMENT

- A. After installation of cantilevers and final stringing of conductors, adjust support assembly components for setting of the final wire stagger, steady arm heel settings, contact wire height and cantilever inclination, so that the OCS alignment is within the specified design tolerances.
- B. Turnbuckles, where used, shall be installed in a manner which will provide 6-inch adjustments in each direction for future maintenance.

3.18 OCS CATENARY ACCEPTANCE MEASUREMENTS AND VISUAL INSPECTIONS

- A. Perform acceptance measures, visual inspections, and related work in accordance with Section 34 30 86, OCS Testing.

3.19 OCS TESTING AND COMMISSIONING

- A. Testing and commissioning of the overhead contact system shall be as specified in Section 34 30 86, OCS Testing.

3.20 DELIVERY, STORAGE, AND HANDLING

- A. All OCS support and registration assemblies, components, and materials shall be protected against damage during handling, shipping, storage, and installation.
- B. Deliver the OCS support assemblies to the site at intervals to ensure uninterrupted progress of the work.
- C. Store material to permit easy access for inspection and identification. Protect steel members and packaged materials from corrosion and deterioration.

- D. All packaged components and/or assemblies shall have a strong waterproof tag securely fastened to the package showing the assembly or component name, number, or identification code.
- E. Packaging and/or packing methods of all assemblies or components shall be subject to approval by Caltrain.

3.21 REPAIRS

- A. Report damage and provide a reason for damage to the equipment.
- B. Repairs to any part of the OCS shall only be made as approved. Damaged components shall be removed from site, or reported along with a proposed repair procedure.
- C. Damage to the galvanizing of poles, assemblies, components, and hardware shall be repaired by the application of a suitable zinc-rich, cold galvanizing repair paint, or an approved equal. Surface preparation and application of the galvanizing repair shall be in accordance with the repair material manufacturer's recommendations.
- D. Repairs of insulators shall not be permitted; replace damaged insulators prior to turnover of system. Make repairs to the OCS only as approved.
- E. Perform touch-up painting and grouting repairs, as necessary, to all catenary-only and joint-use poles damaged or marked during OCS installation. All Work associated with touch-up painting and grouting will be at no additional cost.

END OF SECTION

SECTION 34 30 86

OCS TESTING

PART 1 - GENERAL

1.01 DESCRIPTION

- A. This Section specifies requirements for developing test plans and procedures, supplying testing equipment, conducting factory and field tests for the Overhead Contact System (OCS), preparing test reports, and performing re-tests as required. Testing shall verify compliance with design specifications, ensure system safety, performance, and reliability, and include integration with interfacing systems such as traction power, signaling, and track. All testing shall incorporate safety protocols to protect personnel, equipment, and the public, and demonstrate adherence to industry best practices for mechanical, electrical, and operational integrity.

1.02 REFERENCE STANDARDS

- A. Pertinent provisions of the applicable Standards listed in all OCS Specification Sections for this project shall apply to the work of this Section, except as they may be modified herein, and are hereby made part of this Section to the extent required.

1.03 QUALITY ASSURANCE

- A. Perform the Work included in this Section in strict accordance with the requirements of Section 01 43 00, Quality Control and Assurance and Specification 34 30 03, OCS General Requirements and Interface Requirements.
- B. Testing equipment shall be calibrated to traceable standards, with certificates provided. Quality control measures shall include independent verification of test results, documentation of deviations, and corrective actions. All tests shall be conducted by qualified personnel certified in relevant safety and technical competencies.

1.04 SUBMITTALS

- A. Refer to Special Provisions Section 01 33 00, Submittal Procedures for review process.
- B. Submit a Test Program Plan for approval prior to the submission of Test Procedures (see 1.04-C). The purpose of this plan is to:
 1. Ensure that all of the testing requirements contained in this and other sections of the specifications have been addressed, along with consideration of relevant interfaces with other contractors and Caltrain activities including the rail operations.
 2. Make adequate provisions for testing in the overall test program plan.
 3. To achieve an early mutual understanding on the range, depth and other aspects of OCS tests to be conducted. Provide the test program plan with minimum requirements as indicated below:

- a. A flow diagram indicating the logical sequence of tests, starting with factory tests and continuing on to conclude with field demonstration tests.
 - b. A list of test procedures (by test procedure number) to be submitted, preliminary submittal schedule, a preliminary schedule of tests, and a brief description of each factory and field test. The schedule portion of the program plan shall be a dynamic document to be updated as the program progresses.
 - c. An outline and format of the procedure and test data sheets for each type of test.
 - d. Requirements and recommendations for witnessing of all tests.
 - e. A description of the in-plant and field test organization.
 - f. A detailed safety program defining all precautions to be taken, notices, signs and barriers to be posted concerning the safety of the public, work personnel and equipment. Define all precautionary measures to be taken prior to, during and following the test until such time as normal work is resumed.
- C. Submit test procedures at least 45 days in advance of the scheduled tests. As a minimum, include the following in the test procedure:
1. Objective and scope
 2. Test set-up and test equipment to be used
 3. Personnel required for the test, including Caltrain personnel
 4. Estimated duration of the test
 5. Pass/fail criteria and samples of data sheets to be used.
- D. All tests must be performed in accordance with the approved test procedures. Any deviations will require Caltrain's approval prior to implementation.
- E. Submit all test reports within 15 days after completion of tests. Test reports must contain all the data obtained during tests, an analysis of the data and conclusions from the test pass/fail criteria outlined in the test procedure. A test that fails must be repeated and corrective action taken. To pass the re-test must be outlined in a new test report.
- F. Submit all types of tests to be covered in the Test Program Plan as applicable to the specific project. Include those required for testing and commissioning the Overhead Contact System following completion of construction, as specified in Part 3 of this Section. The following commissioning tests are required:
1. Acceptance measurements
 2. Visual inspection of completed OCS

3. Clearance envelope tests for pantograph
 4. Overhead Contact system electrical tests
 5. Live line run testing
- G. Submit calibration certificates for all testing equipment.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Furnish the details (including calibration) of the height and stagger gauges, and all other equipment necessary to record the Acceptance Measurements to Caltrain for information.
- B. Furnish all electrical equipment and tools required to test and record the electrical tests. All test equipment must have been calibrated within the 6 months prior to the test and certificates of all equipment calibrations must be provided prior to the scheduling of any electrical tests.

PART 3 - EXECUTION

3.01 FACTORY TESTING

- A. Conduct factory acceptance tests (FAT) for critical OCS components such as insulators, conductors, fittings, and assemblies, per approved procedures.
- B. Tests shall include mechanical strength, electrical insulation, material certification, and functional performance under simulated conditions.
- C. Submit FAT reports demonstrating compliance before shipment.

3.02 ACCEPTANCE MEASUREMENTS

- A. Upon completion of OCS construction, measure the contact wire height, stagger, and other required dimensions and record the readings on the Acceptance Measurement Form.
- B. Schedule acceptance measurements in advance. Perform measurements only in times of calm (less than 10 mph wind), dry weather, with either steady sunshine or continuous cloud cover.
- C. Prepare a project-specific Acceptance Measurement Table that includes the following information:
 1. Track designation.
 2. Wire Run Number as indicated on the OCS Layout Plans.
 3. Drawing number(s) where the structures of the Wire Run are shown.
 4. Name(s) of person(s) performing the acceptance measurements.

5. Sheet number of a Wire Run set.
6. OCS equipment type or style being measured.
7. Temperature of the conductors (messenger and/or contact) in degrees F during the time of measurement.
8. Weather condition during time of measurement (e.g., windy, raining).
9. The date the measurements are made.
10. Station location of the structure in feet (stationing reference) as indicated.
11. Horizontal distance of the pole to the closest served adjacent track centerline(s) measured from the inside running edge of the nearest rail to the face of the pole.
12. Cross-level difference of the two rails measured to the structure station (the actual track super-elevation at the structure).
13. Lateral distance measured at the structure from the contact wire to the vertical or super-elevated centerline of the track (referred to as stagger).
14. The vertical distance between the contact wire at the structure measured from the mean rail level (referred to as contact wire height at the support).
15. The same as (13) except measured at mid-span (referred to as actual track super-elevation at mid-span).
16. Distance between the contact wire and the vertical or super-elevated centerline of the track measured at mid-span (referred to as mid-span offset).
17. The same as (15) except measured at mid-span (referred to as contact wire height at mid-span).
18. The average of the contact wire heights at the structures (at each end of the span) minus the contact wire height at mid-span.
19. The rate of change of contact wire between the structures. This is equal to the difference of contact wire heights at each structure divided by the span (referred to as gradient).
20. Vertical distance (system height) measured at the structure between the contact wire and the messenger wire.
21. Rise or fall of balance weight from median position (at design temperature).
22. The vertical distance between the underside of the bridge and the vertical or super-elevated centerline of the track measured at low point of bridge, each bridge face and center.
23. Electrical clearance from the messenger or contact wire support to underside of bridge, with uplift force of 25 lbs. on the contact wire at the

- point of measurement, measured at each bridge face and at the midpoint of bridge.
24. Electrical clearance from the ATF to the underside of bridge, measured at each bridge face and at the mid-point of the bridge.
 25. At overlaps and turnouts - height of in-running and out-of-running contact wire above rail – referenced above mean rail level at each structure.
 26. Comments or remarks as required.
- D. Acceptance Measurements form will be used to determine compliance with the OCS design. The form will identify necessary corrections to be performed.
 - E. Make corrections, except for adjustments required by Caltrain which are changes beyond the requirements specified in the contract documents and shop drawings.
 - F. After the execution of corrections, re-measure and record affected data and submit the results to Caltrain.
 - G. The work of this section shall not be complete until all corrections are performed and accepted.
 - H. Submit completed Acceptance Measurements Tables in accordance with the contract documents and this specification.

3.02 VISUAL INSPECTION OF COMPLETED OVERHEAD CONTACT SYSTEM

- A. At Contact Wire Level (in hi-rail bucket truck or platform truck), make the following visual checks, and promptly remedy all unsatisfactory conditions detected:
 1. Check fitting and tightness (torque) of all components and fasteners.
 2. Check security of the split pins for 90 degree minimum bend and ensure locknuts are secure.
 3. Check contact wire for kinks, rolls, and damage.
 4. Check messenger wire for damage to strands.
 5. Check ATF for damage to strands.
 6. Check static wire for damage to strands.
 7. Check for correct steady arm fittings.
 8. Check heel settings of steady arms.
 9. Check that jumpers are of correct type, have adequate travel capability, are properly fitted, are pointed in the correct direction, and are well formed so as to prevent a hard spot and avoid fatigue failure.
 10. Check posture of auto tensioning devices and of a termination yoke plate
 - a. Check FTA and MPA

11. Check that cantilever hinge fittings have freedom to move under load.
 12. Check that a wire passing through a cantilever and not attached to it will clear any part of this cantilever by at least 3" throughout the auto-tensioned (AT) operational range of +20° F to +145° F.
 13. Check for electrical air clearance and insulation between adjacent or crossing OCS wires.
 14. Check all OCS installations for locations of possible interference with passage of pantographs, including spots where pantographs could tangle with wires or suspension assemblies.
- B. From ground level, make the following checks:
1. Check that auto tensioning devices are positioned correctly (vertically), have freedom to travel and that balance weights do not bind, rub on the surface of the OCS pole. Note: this check may require the use of aerial lift equipment.
 2. Check that cantilevers and pull-off assemblies have correct along-track offset.
 3. Check that headspan and cross-span assemblies have correct along-track offset.
 4. Check that hangers are complete, uniform and plumb, and installed within design position.
 5. Check out safety requirements in accordance with NESC and other applicable safety codes.

3.03 CLEARANCE ENVELOPE TESTS FOR PANTOGRAPH

- A. The purpose of these tests is to verify the mechanical and electrical clearances of the electrical locomotive's pantograph on each section of the system. The tests shall be conducted after all installations are complete and after the Acceptance Measurements have been made, submitted and approved. Any section found to have insufficient clearance shall be adjusted to provide the required clearance.
- B. Pantograph Clearance Envelope: Provide rail mounted height stagger gauge for the initial tests, having the same dynamic profile as the EMU's pantograph. This gauge shall be used to verify the mechanical clearances between the pantograph and OCS components such as the heels of steady arms and contact wire clamps, and the electrical clearances between the OCS/pantograph combination and civil structures, such as at overhead bridges, tunnels and station platforms.

3.04 OVERHEAD CONTACT SYSTEM ELECTRICAL TESTS

- A. General Test Requirements:
1. All OCS conductors, feeder cables, disconnect switches, section insulators and phase breaks must be confirmed via field testing after installation that

they meet all electrical performance requirements of the contract documents.

B. Loop Continuity Test:

1. Loop continuity tests shall be performed to ensure continuity and resistance is as expected. The loop shall include the Messenger and Contact Wire and the Neutral Return system including running rails, impedance bonds and the static wires.
2. At one end of the test section, install test lead from OCS near an open disconnect switch to the running rail. Connect 24 v battery to the other end of the test section. Record voltage and current. The test section shall not exceed one mile unless otherwise approved by Caltrain.
3. Calculate the expected loop resistance including messenger, contact wire, impedance bonds, static wire if connected to impedance bonds in the test section, and the length of running rails in the test section. Refer to the Neutral Return Schematics to determine quantity of parallel running rails and static wire connections in the test section.
4. If the loop resistance is over five percent greater than the expected resistance as calculated, then the loop shall be investigated, and repairs conducted. Retest to verify resistance is as expected by calculation.

C. Voltage Withstand Testing

1. A Voltage Withstand test, also referred to as a High Potential (Hi-Pot) Test, shall be performed on all OCS energized conductors and equipment using the test voltages denoted below. The voltage withstand tests serve the following purposes:
 - a. Components such as insulators and ATF cables are checked for leakage.
 - b. The electrical withstand of minimum clearance areas such as at overhead bridges and tunnels are verified under static conditions.
 - c. The electrical withstand of section insulators, phase breaks and disconnect switches are verified.
 - d. The test provides an OCS performance basis for newly constructed OCS and a reference for periodically checking for any reduction in the insulation level of the OCS sections, by comparing voltage and leakage current with the previously measured values.
2. A nominal DC Hi-pot voltage of 51 kV (2 times nominal plus 1 kV) shall be used for the test. Hi-pot shall be carried out on the OCS sections as soon as possible after the continuity tests have been completed in the sequence of section lengths. It is to be made sure that all the sections being tested are electrically continuous and are subjected to test voltage. Leakage currents values in milli-amperes shall be recorded and re-computed for section lengths of 1-2 miles for further evaluation by Caltrain.

3. Procedure for OCS Along Track: Along-track feeders which are electrically common to the OCS should be connected to the OCS but disconnected from the substation. Feeder cables shall be disconnected from the section under test. Adjacent OCS sections which are electrically isolated from the section under test shall be grounded by connecting the OCS to the rails. The full test voltage must be sustained for duration of 10 minutes, after incrementally ramping up the test voltage in 5 kV increments up to the nominal test voltage. The test voltage shall be held for 30 seconds at each increment. The leakage current at each value shall be measured and recorded, together with weather conditions and temperature.
4. The leakage current at the final test voltage shall be measured and recorded together with the weather conditions and temperature.
5. Just prior to the voltage withstand test (Hi-pot), the conductors and equipment involved shall undergo an insulation resistance and continuity test (Loop Resistance) utilizing a megger tester at 1 kV for a duration of one minute.
6. OCS conductors and ATF shall be tested separately.
7. OCS conductors for each individual track shall be tested separately.
8. All surge arresters and transformers shall be disconnected from the OCS and feeders prior to the testing.
9. OCS and ATF will be tested in discrete sections, typically from one point of feed (i.e., a substation, switching station or parallel feeding station) to the most adjacent point of feed.
10. Precautions: The Hi-pot measurements require application of high voltage to the OCS. Proper regard must be paid to safety. Test zones shall be clearly identified. All safety requirements established in the Safety program concerning the public, work personnel and equipment shall be strictly enforced. Personnel not directly associated with the test should be clear of the tracks. Sections of OCS and associated feeders under test shall be isolated from the adjacent sections of the system, and all OCS sections adjacent to the section under test shall be grounded.

3.05 INTEGRATED TESTS

- A. Following the successful testing of the Overhead Contact System as specified in this Section, assist Caltrain in performing integrated tests with other Systems (i.e. signals, traction power, vehicles, etc.).
- B. Sectionalization Testing:
 1. General: The sectionalization tests shall be performed on the Overhead Contact System to demonstrate the test sectionalization scheme and operation/functionality of disconnect and/or bypass switches and section breaks.
 2. Prior to commencement ensure that all pre-cursor inspections and tests have been completed and associated test reports reviewed and approved.

3. The pre-requisites for energization, as specified in this Specification Section are completed.
 4. All parties working in the vicinity of the OCS are notified prior to the test.
 5. Energize at 25kV all or part of the OCS that has been approved to be tested.
 6. Starting from pre-agreed starting point and working toward the pre-agreed finishing point the contractor shall operate all AC feeders, disconnect and bypass switches within the pre-determined test area to:
 - a. Demonstrate the TES sectionalization scheme for each line section, at each substation and at each special track-work location.
 - b. Demonstrate the operation/functionality of disconnect and/or bypass switches.
 7. Verify SCADA indications received at CCF correctly indicate the status of the sectionalization.
- C. Dead Run Tests
1. Pantograph tests on the OCS (known as "Dead Car Pull Tests") will be performed during integrated testing using an electric locomotive (supplied by Caltrain) or pantograph fitted on track vehicle with the pantograph in normal contact with the de-energized contact wire. These tests are performed to assure a smooth, shock-free passage of the pantograph, especially at turnouts, section insulators, phase breaks, overlaps and locations where the wire height changes. Particular attention will be focused on wire takeover at overlaps, turnouts and crossovers, and to confirm the lack of hard spots at all locations. The contractor shall be responsible for all adjustments required as a result of these tests. Any adjustments required shall be performed at the expense of the contractor.
- D. Live Run Tests
1. Once the "Dead Car Pull Tests" are completed, and any required corrections are made, Caltrain will operate an electric locomotive on the energized Overhead Contact System starting at 5 mph and increasing at 5 mph increments until maximum design speed in the track segment is achieved in both directions to verify the OCS performs as required and to confirm that there is no arcing at any locations on the OCS that is deemed by Caltrain to be prejudicial to good current collection and injurious to the expected service life of the contact wire. Any repairs deemed necessary will be made immediately. After the successful completion of the "Dead Car Pull Test" and any resulting punch list items, video record the OCS in its entirety (by means of a video camera mounted on the roof of an electric locomotive during a live train test run) and furnish two (2) copies of the video.
- E. Contractor shall provide Systems Integrated Test Procedures for integrated testing.

END OF SECTION

SECTION 34 31 03

GENERAL TRACTION POWER REQUIREMENTS

PART 1 – GENERAL

1.01 TRACTION POWER SUBSTATIONS, SWITCHING STATIONS, AND PARALLELING STATIONS

A. General

1. Traction Power Substations (TPS), Switching Stations (SWS), and Paralleling Stations (PS) shall include the specified indoor traction power equipment and associated basic electrical materials housed in a factory pre-packaged switchgear and control enclosure as well as all outdoor equipment and material described in these specifications and shown on the Contract Drawings. The traction power equipment and associated pre-fabricated enclosures shall be of proven design for the intended purpose. The traction power equipment and prefabricated enclosures shall be products of manufacturers experienced in and regularly engaged with providing similar fully integrated factory pre-packaged equipment and outdoor pad mounted traction power equipment for electrified rail systems.

B. Application

1. The TPS yard equipment will be used to transform 115 kV primary power provided by Pacific Gas & Electric (PG&E) to 27.5/55 kV single phase power for electrified railway operation.
2. At all Traction Power TPS, SWS, PS and Wayside Power Cubicles (WPC), an auxiliary power source will be provided directly from the local utility.

C. Seismic Design

1. The traction power equipment and supporting structures shall be designed to withstand the seismic forces applicable to the project area, which is located within a seismic zone 4 region.
2. TPF including WPCs seismic design practice shall comply with all applicable National, State and local standards and codes.
3. Substation design shall be in accordance with IEEE 693, Recommended Practice for Seismic Design of Substations.

D. Utility Company Service

1. The traction power substations will receive 115 kV, 60 Hz, single phase power from PG&E for Traction Power service.

E. Traction Power Equipment

1. Equipment Interchangeability: Similar equipment at all traction power substations, switching stations, and paralleling stations

shall be of the same design and manufacture. Parts shall be interchangeable between similar equipment.

2. Equipment Arrangement: Typical equipment arrangements and locations within the traction power substations, switching station, and paralleling stations shall be as indicated on the Contract Drawings.
 3. Note that drawings arrangements reflect use of gas insulated switchgear using fixed mounted breakers.
- F. The Contract Drawings define functional requirements for the traction power system equipment. Additional functional requirements are defined in the Contract Specifications. The Contract Drawings and Contract Specifications shall form the basis for the Contractor to design, develop and provide all details, appurtenances and devices necessary to furnish a complete and operable traction power system, including its interfaces with the existing Caltrain Systems, PG&E and other subsystems.

1.02 ABBREVIATIONS

- A. The following abbreviations augment those identified in other sections of the Specifications:

A or Amp	Ampere
AAR	Association of American Railroads
AC	Alternating current
AEIC	Association of Edison Illuminating Companies
AF	Frame Amps
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
Al	Aluminum
A/M	Automatic/Manual
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASTM	American Society for Testing & Materials
ANSI	American National Standards Institute
AT	Autotransformer
ATS	Automatic Transfer Switch
AUX	Auxiliary
AWG	American Wire Gauge

AWS	American Welding Society
APCC	Auxiliary Power Control Cabinet
BIL	Basic Impulse Level
BKR	Breaker
C	Celsius
CAT	Catenary
CB	Circuit Breaker
Ckt	Circuit
CS	Control Switch
CT	Current Transformer
DC	Direct current
DISC SW	Disconnect Switch
Ea	Each
EMF	Electro-Magnetic Field
EMH	Electric Manhole
ETC	Emergency Trip Control
ETS	Emergency Trip System
F	Fahrenheit
Fdr	Feeder
FO	Fiber-Optic
FRA	Federal Railroad Administration
FRE	Fiberglass-Reinforced Epoxy
FTA	Federal Transit Administration
Gnd	Ground
GRS	Galvanized Rigid Steel
HDPE	High Density Polyethylene
HH	Handhole
Htr	Heater
Hz	Hertz (Cycles/Sec)
IBC	International Building Code
IEC	International Electrotechnical Commission

IEEE	Institute of Electrical & Electronics Engineers
IFTC	(SCADA) Interface Terminal Cabinet
kcmil	Thousand circular mils
kV	Kilovolt
kVA	Kilovolt-Amperes
kW	Kilowatt
LA	Lightning Arrester
LED	Light emitting diode
mA	Milliamperes
μA	Microamperes
MAX	Maximum
MH	Manhole
Min	Minimum
MNHR	Man hour
MPH	Miles per hour
MTBF	Mean Time Between Failure
MW	Megawatt
NC	Normally Closed
NEC	National Electrical Code
NEG	Negative
NEMA	National Electrical Manufacturers Association
NETA	InterNational Electrical Testing Association
NESC	National Electric Safety Code
NFPA	National Fire Protection Association
NIC	Not In Contract
NO	Normally Open
NTP	Notice To Proceed
NTS	Not To Scale
OCS	Overhead Contact System
O&M	Operation & Maintenance

PB	Pushbutton (on electrical diagrams)
PH	Phase
POS	Positive
psi	Pounds Per Square Inch
PT	Potential Transformer
PVC	Polyvinyl-Chloride
ROW	Right Of Way
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition
SSPC	The Standards for Protective Coatings
SPSS	Signal Power Supply Station
STA	Station
Sw	Switch
TB	Terminal Block
TES	Traction Electrification System
TPF	Traction Power Facilities
TPS	Traction Power Substation
Typ	Typical
UL	Underwriters Laboratory
V	Volt
VT	Voltage Transformer
WPC	Wayside Power Cubicle
XFMR	Transformer

1.03 RELATED SECTIONS

- A. Related sections for traction power equipment are listed under the individual Sections applicable to each type of equipment.

1.04 REFERENCES

- A. References for various industry standards and codes for traction power equipment are listed under the individual Sections applicable to each type of equipment.

1.05 EQUIPMENT IDENTIFICATION

- A. Equipment identification, by alpha-numerical references, is assigned to major

items of equipment and assemblies, as indicated. These references shall be used on related shop and working drawings, correspondence, documents, and identification nameplates.

1.06 LICENSING AND CERTIFICATION REQUIREMENTS

- A. All work specified in these Specifications shall be performed by State of California unlimited licensed electricians working for an Electrical Contractor licensed by the State of California, skilled and experienced in the installation of the particular products specified in these Specifications, except as follows:
1. Testing of insulated cables and other testing as specified in other Sections of these Specifications shall be performed by NETA certified technicians.
 2. Welding shall be done by qualified and certified welders who make only those welds for which they have been qualified in accordance with AWS, applicable ASME standards, or other approved qualifying procedures. Records of welder qualification tests shall be made available for review upon Caltrain's request.
 3. Electrical work performed at the Traction Power Equipment Manufacturer's Plant for the purpose of installing electrical equipment within pre-packaged 25 kVAC switchgear and control buildings shall be performed by electrical workers skilled in the installation of electrical equipment, knowledgeable of the NEC reference standards, and certified by the manufacturer's Quality Assurance plan. Acceptable certification includes an unlimited journeyman's electrician's license or establishing the equivalency there of to the satisfaction of Caltrain.
 4. Unskilled or inexperienced workers shall not be permitted to install equipment whether at the factory or in the field or perform electrical work of any kind on this project.
 5. Unlicensed workers shall not perform the installation of conduit, or of insulated power cables in conduit wireways or work inside traction power substations, switching stations and paralleling stations, except as specified herein.

1.07 BASIC MATERIALS FOR INSTALLATION

- A. All material furnished under these specifications shall be listed and labeled by Underwriters Laboratories, Factory Mutual, wherever standards have been established by these agencies for these materials, and these are acceptable to the Authority Having Jurisdiction. Other materials that are not listed or labeled require approval by Caltrain prior to acceptance. Products which have not been tested or certified for the use intended shall not be used when equivalent listed or labeled materials are available.
- B. All material shall be new, unused, in first class condition, suitable for the use intended, and of the manufacturer's latest standard design. All materials and equipment provided shall fit within the space provided and shown on the Plans.
- C. All materials and equipment provided shall be standard products of manufacturers regularly engaged in the production of such material and

equipment. As deemed necessary by Caltrain, the manufacturer may be requested to provide an experience list of similar equipment provided for use in a similar operating environment.

- D. Where two (2) or more units of the same class of material or equipment are required, products of a single manufacturer shall be provided. Similar component parts of different larger assemblies are not required to be the products of the same manufacturer. Discontinued materials or products shall not be permitted.
- E. Each type of material and equipment shall be of the same manufacture and quality throughout the work.

1.08 SHIPPING AND ON-SITE STORAGE OF EQUIPMENT AND MATERIAL

- A. All equipment and material shall be protected and maintained in new condition throughout the contract period until final acceptance by Caltrain.
- B. All equipment and material intended for use on this Contract shall be shipped and stored such that damage or reduction in life is prevented.
- C. All stored material subject to corrosion shall be protected by waterproof covers or coatings. Materials and equipment shall be stored under cover and off the floor or ground.
- D. Insulated cable ends shall be sealed and stored in a dry location to prevent the entry of moisture into the cable conductors.
- E. All equipment shall be stored with all ports, covers, and all other enclosure openings closed to prevent ingestion of dirt or moisture, and kept dry and free from condensation.
- F. Special care and manufacturer's recommendation for equipment storage shall be followed for power transformers, autotransformers, power circuit breakers, disconnect switches, metering instrument transformers, and support insulators prior to installation.
- G. All material with a defined life expectancy shall be clearly marked with expiration data and shall not be used beyond the expiration date.
- H. All material with special handling or storage requirements shall be handled or stored according to the manufacturer's requirements.
- I. All material shall be clearly marked and stored with appropriate nomenclature to prevent misapplications.
- J. Rejected or used material, or material which is not in conformance with the Contract requirements shall be so marked and promptly be removed from the job site.
- K. All equipment storage shall be at the Contractor's project facility, unless Caltrain provides designated on-site storage areas.

1.09 CORROSION CONTROL

- A. All material and equipment shall be designed to ensure satisfactory operation and life in the environmental conditions that exist where the material or equipment is installed. The finish of equipment or material shall be provided

exactly as shown or specified. Where no finish or color is specified, material and equipment shall be provided which is suitable for the environment in which it is installed, and shall be approved by Caltrain prior to installation.

- B. In wet locations (anywhere along the ROW when not housed or under cover), corrosion resistant stainless steel enclosures rated NEMA 4X per NEMA Std. 250 shall be provided unless otherwise indicated. In damp locations, NEMA 12 enclosures rated in accordance with NEMA Std. 250 shall be provided unless otherwise indicated, and shall be fabricated from painted galvanized or stainless steel. In wet and damp locations, all fittings or supports shall be corrosion resistant, and be hot-dipped galvanized or as otherwise specified. In exposed dry locations, corrosion resistant painted finishes may be used for equipment and enclosures as approved by Caltrain.
- C. Connections of dissimilar materials are permitted only at permanent connections and with suitable electrochemical isolation. All such isolation treatments shall be permanent and not require maintenance or replacement for the life of the equipment or installation. Dissimilar materials are not permitted at electrical connections or connections requiring disassembly for maintenance or for removal and replacement of equipment.
- D. Wherever painted ferrous metal is called out for application in a damp or wet environment, or enclosures or boxes with a NEMA 12 or 3X rating are called out, the metal shall first be primed with an approved rust inhibiting primer, and finish painted with an approved finish coat(s) of corrosion resistant paint. The finish shall be polyurethane enamel applied over a vinyl wash primer, or an approved equal product. The applied thickness shall be in accordance with manufacturer's instructions. All ferrous metal equipment or material surfaces located above- ground which are capable of rusting or oxidation shall similarly be cleaned and painted.
- E. Ferrous equipment or material used below grade and not concrete encased such as direct buried steel conduit, shall be hot-dipped galvanized and coated with a minimum of two coats of coal tar epoxy applied to 8 mils (0.203 mm) dry film thickness per coat. Approved manufacturers of coal tar epoxy coatings are DuPont de Nemours Company, Koppers Company, and 3-M Company.
- F. Wherever "galvanized" or "hot-dipped galvanized" is called out in the Specifications, the material shall be coated in accordance with ASTM A123. Wherever "Mechanically Galvanized" is called out in the Specifications, the material shall be galvanized in accordance with ASTM B 695. Galvanized steel sheet shall conform to ASTM A653/A653M, coating designation G60 minimum.
- G. Wherever materials are called out as "hot-dipped galvanized" or "galvanized", the coating is intended to be applied in addition to normal manufacturer's finish. Some materials or products specified which are not readily available in the specified hot-dipped finish, shall be "custom" hot-dipped after manufacture by an independent galvanizer. Where finished are called out as galvanized and the specified product cannot be either manufactured with a hot-dipped finish, or cannot be hot-dipped galvanized after manufacture, the specified product shall be furnished with a finish that will perform equal to hot-dipped galvanized as approved by Caltrain.
- H. Where field touch-up of galvanized ferrous material is required, whether in a dry or wet location, coat with a zinc rich paint, as manufactured by ZRC or

approved equal, after cleaning with a solvent to remove oil as recommended by the paint manufacturer.

1.10 ENVIRONMENTAL CONDITIONS

- A. Elevation: The lowest and highest part of the alignment is located 10 feet and 155 feet respectively above sea level.
- B. Temperature: The annual atmospheric ambient temperature shall be assumed to range between 15 and 108 degrees F.
- C. Relative Humidity: The annual relative humidity shall be assumed to range between 5 and 95 percent.
- D. Typical Wind Conditions: The following wind conditions shall be assumed:
 - 1. Maximum Sustained 2-minute Wind: 58 miles per hour.
 - 2. Maximum Sustained 5-second Wind: 59 miles per hour.
 - 3. Peak Recorded Gust: 74 miles per hour.
- E. Rainfall: The following rainfall levels shall be assumed:
 - 1. Normal Annual: 15 to 20 inches.
 - 2. Maximum in twenty-four-hour period: 2 inches.
 - 3. Maximum in one-hour period: 1.5 inches.
 - 4. 90% of Average Annual Precipitation occurs between November and April.
- F. Floods: The TES shall be designed for the peak run-off from a 100-year storm.
- G. Snowfall, Ice Pellets, and Icing
 - 1. The location of the alignment experiences minimal levels of snowfall, ice pellets, and icing; and therefore, their impact on the design of the TES shall be ignored.
- H. Number of Thunderstorm Days per Year: Assumed to be fewer than 10 days.
- I. Fog: Heavy fog is common to some areas of Caltrain’s alignment and therefore shall be assumed, for design purposes, for the complete alignment.
- J. Seismic: Caltrain’s alignment is located in a seismic zone 4 area per the UBC.
 - 1. The TES shall be designed to withstand settlement and forces associated with the maximum credible earthquake along the Caltrain Alignment. Refer to the Caltrain 25kV AC Electrification Standard.
 - 2. The requirements pertaining to seismic design requirements, as specified in NESC and Caltrain’s Standards, shall be read in conjunction with the requirements specified herein.
- K. Atmospheric Pollution / Contamination

1. See Air Quality Analysis, dated July 2002, and Chapter 3 Section 3.3 of the Environmental Assessment / Final Environmental Impact Report for Caltrain's Electrification Program for information pertaining to existing atmospheric pollutants / contaminants along the Caltrain alignment.
- L. Hazards and Hazardous Materials
1. See Chapter 3 Section 3.7 of the Environmental Assessment / Final Environmental Impact Report for the Caltrain Electrification Program.
- N. Noise and Vibration
1. See Noise and Vibration Study and Chapter 3 Section 3.11 of the Environmental Assessment / Final Environmental Impact Report for Caltrain's Electrification Program.
 2. The noise levels at traction power facilities shall comply with local jurisdictional requirements, as specified in the following documents:
 - a. Caltrain Draft EIR Report (dated April 2004), Section 3.11.1.2 Page 3 – 92 & 93.
 - b. Caltrain Noise and Vibration Study (dated November 2003) Section 5.5, pages 56 to 58.
- O. Electromagnetic Compatibility (EMC)
1. Installer / Supplier shall fulfill all applicable EMC requirements in Chapter 6 Electromagnetic Interference and Compatibility.
 2. Traction power equipment suppliers shall certify that equipment conforms to the limits standards as specified in the EMC Control Plan.

1.11 EQUIPMENT SEISMIC REQUIREMENTS

- A. All equipment and raceways shall be braced against earthquake by securely fastening in place. All freestanding equipment such as switchgear, control and relay panels shall be braced at the top to prevent movement, and fastened at the bottom to prevent sliding or walking. Floor mounted power circuit breakers, power transformers, autotransformers, station service transformers, AC switchgear, and control switchboard shall be securely fastened to the floor using concrete expansion anchors or other appropriate bolted fastening system.
- B. Conduit racks and cable trays shall be supported laterally using braces fabricated from channel and fittings. Supports shall be sufficient to withstand the seismic load, and in addition shall be located within 2 feet (600 mm) of each bend or tray dropout, and spaced no greater than 25 feet (7630 mm) apart.
- C. A Seismic Bracing and Anchorage Plan shall be developed and submitted for approval as part of the Field Installation Plan detailed in this specification. The plan shall address anchorage of the power transformer, autotransformer, station service transformer, AC switchgear, control switchboard, conduit racks,

cable tray, and battery and battery rack. The plan shall include stamped calculations by an Engineer registered in the State of California which demonstrate the suitability of the proposed anchorage and bracing.

1.12 FIELD INSTALLATION PLAN

- A. The Contractor shall submit a field installation plan and procedures to Caltrain and obtain approval prior to beginning any work in the field. The plan shall be submitted for approval no later than 60 days prior to equipment installation. The Contractor shall have conducted site surveys and any other tasks required to verify that the proposed installation can be installed as designed. Any obstructions or issues preventing construction and installation of the designed facilities shall be brought to the attention of the Caltrain Project Manager without delay. The installation plan and procedures shall address the following items:
1. The number of individual pre-wired units to be shipped from the factory and the status of the testing completed on each unit.
 2. Handling and shipping preparations for each unit.
 3. Storage plans for all equipment and other material not immediately installed at each location upon arrival.
 4. Unloading and inspection procedures for each unit upon arrival at the site.
 5. Installation procedures for each unit.
 6. Testing procedures to be completed prior to Engineer's Acceptance Test described in Section 34 31 76.
 7. Conductor pulling calculations and installation methods as described below.
 8. Field Testing plan, in accordance with Section 34 31 76, TPF Testing and Commissioning. The Protection settings report must be submitted by the Contractor and approved by Caltrain prior to the submission of the field testing plan.
 9. Seismic Bracing and Anchorage Plan which includes seismic bracing and anchorage calculations and installation details and specifications for each type of equipment to be installed. Special attention shall be paid to the high voltage power circuit breakers and disconnect switches, power transformers, autotransformers, AC switchgear and control switchboard.
 10. Completion of wiring and installation drawings (Equipment installation shall not commence until shop drawing submittals have been approved by Caltrain).
 11. Coordination with the Electric Utility for obtaining electrical service at each site, and arranging for final electrical service and energization for each traction power substation.

1.13 CABLE PULLING CALCULATIONS

- A. As part of the Field Installation Plan, the Contractor shall perform pulling calculations in accordance with the cable manufacturer's recommendations, and these specifications. The calculations shall be made by an Electrical Engineer registered in the State of California, and bear the seal and signature of the Engineer who is responsible for the calculations. Calculations shall be made for all conductors including 46 kV class cables and multi-conductor control cable when installed in conduit under any of the following conditions:
 - 1. The conduit run exceeds 100 feet (30,480 mm) vertically.
 - 2. The conduit run exceeds 300 feet (91,400 mm) horizontally.
 - 3. The conduit run contains a total of over 180 degrees of bend.
- B. The Contractor shall also provide calculations for any additional run under any condition when requested by Caltrain. The calculations shall establish that the Contractor's cable installation detailed in the Field Installation Plan can be implemented without damage to any wire or cable.
- C. For pulling calculations, consideration shall be given to the following parameters: percentage fill, coefficient of friction, clearance, configuration, jam ratio of the cables and conduit, weight correction factor, bend radii, training of the cables on entering and exiting the conduits, maximum allowable tension, sidewall load, the method of attaching the conductors to be pulling equipment, and weight of the cables. These factors shall be calculated for each pull as required. The Contractor shall not exceed the maximum allowable values of sidewall pressure, pulling strain on conductors or sheath, limits of pulling device, and pulling tension.
- D. The Contractor shall not exceed the following guidelines, unless approved by Caltrain:
 - 1. The maximum pulling strain on the cable with a pulling eye attached to the conductors is a function of the conductor area as follows: $TM = 0.008 \times n \times CM$, where TM = Maximum tension (kg), n = number of conductors, CM = area of each conductor (square mm).
 - 2. When a basket-weave grip is used in lieu of a pulling eye, the maximum tension shall not exceed the value calculated for the pulling eye method or 1,000 lbs (454 kilogram) per grip, whichever is less.
 - 3. The sidewall pressure loads shall not exceed 500 lb/ft (678 N-m) of bend radius, or the wire and cable manufacturer's recommendation, whichever is less.
 - 4. The jam ratio shall not fall between 2.8 and 3.2.
 - 5. The coefficient of friction for the cables with lubrication shall be taken to be 0.35.
- E. Cable pulling calculations shall be submitted to Caltrain for approval. Cable shall not be installed until the Contractor receives approval from Caltrain for both the pulling calculations and the cable installation described and submitted in the Field Installation Plan.

1.14 ELECTRIC UTILITY COORDINATION AND TEMPORARY POWER REQUIREMENTS

- A. After equipment installation, the Contractor shall protect the buildings and outdoor traction power equipment from damage from moisture by maintaining heat within each of the pre- packaged AC switchgear, control and relay panels, and outdoor traction power equipment. The Contractor shall arrange with the Electric Utility to provide temporary electrical service as needed to each of the building or to provide temporary service equipment sufficient to power temporary heaters.
- B. The Contractor shall pay for all permits for temporary power, and maintain the temporary electrical service in operation until the permanent electrical service to each TPSS/SWS/PS is energized and the final acceptance by Caltrain.
- C. At all service locations requiring utility metering, utility approval of the electrical service plan as part of the Field Installation Plan shall be given before proceeding with construction. Electrical service requirements shall be coordinated with the Electric Utility, and all material and labor to accomplish the services shall be included in the Contractor's bid.
- D. Metering enclosures shall be furnished in accordance with PG&E standards and installed by the Contractor. The foundations for the metering enclosures, grounding wires and conduit system from the metering equipment to the metering enclosures shall be provided and installed by the Contractor in accordance with PG&E Electric Revenue Metering Requirements. PG&E will furnish metering conductors, PTs and CTs, as well as perform testing and final connections.

1.15 SCHEDULING OF SUBMITTALS

- A. Within 120 calendar days after Notice to Proceed, the Contractor shall submit the following schematic-stage drawings and calculations as a minimum.
 - 1. Outline drawings of all major equipment and outdoor equipment support structures, indicating overall dimensions, space requirements, location of control and protective devices on panels and reference tables to other drawings furnished. The submittal shall include:
 - a. Front view of AC switchgear and associated equipment, showing all door and panel mounted devices, equipment and device nameplates and door swings; and
 - b. Top view of the running rail return system, and
 - c. Front views of the auxiliary control panel and AC and DC distribution panels.
 - 2. Floor plans and elevation (section) views of substation (TPS/SWS/PS) enclosures, showing dimensions, openings for power and control cable conduits, door openings and swings, HVAC equipment, station battery system, miscellaneous remaining equipment, major equipment weights, overall weight, and center of gravity.
 - 3. Drawings of substation gantries, foundations, steelwork, overall substation layout and clearances, manufacturer's product data, and

- grounding plans. etc.
4. Top and bottom views of equipment, showing available space for entrance of power and control circuit wiring from the top or bottom, as specified and entry buses.
 5. Section views of each non-identical switchgear unit showing buses and bus supports, location of circuit breakers in permanent connected positions and the location of outgoing power and control terminals.
 6. Front view and side panel views of each non-identical control compartment unit.
 7. One line relay & metering diagram of equipment supplied, showing all power and auxiliary circuits, protective devices, and the location of all current, potential and auxiliary transformers with the devices energized by them.
 8. Schematic diagrams of traction power transformers, autotransformers, circuit breakers, auxiliary power system, station battery system, disconnect switch motor operators, and associated circuit connections, controls and alarms, as follows.
 - a. Schematic diagrams shall be self-explanatory and shall be specifically prepared for this Contract and shall include AC schematic (full line) and 125 VDC elementary diagrams for all circuits.
 - b. Schematic diagrams shall show originating and terminating terminal block numbers for all wiring which enters or leaves an equipment compartment ("external wiring"). These terminal block numbers shall match the terminal block numbers shown on subsequent wiring diagrams.
 9. Internal connection diagrams of devices, including relays and meters.
 10. Contact development of control, selector and instrument transfer switches, test switches and lockout relays.
 11. Equipment trip and lockout schedule, in tabulated form.
 12. Calculations of 125 VDC control power requirements and for the sizing of station battery, charger, and DC distribution panel in accordance with Section 34 31 26, TPF Batteries and Accessories.
 13. Calculations for sizing of enclosure HVAC system heating and cooling equipment and the enclosure lighting in accordance with Section 34 31 89, TPF Enclosures.
 14. Calculations for confirming the auxiliary power requirements in accordance with Section 34 31 29, TPF Auxiliary Power Systems.
 15. Drawings and design calculations for the enclosure lighting requirements in accordance with Section 34 31 89, TPF Enclosures.
 16. Equipment test plans in accordance with Section 34 31

76, TPF Testing & Commissioning.

17. Short circuit and EMI studies.

- B. After the return of the approved schematic-stage drawings and calculations marked "For Construction", or equivalent, the following drawings, calculations and other documents shall be submitted within 90 days.
1. Dimensioned general substation enclosure arrangement plans and elevation views, locating all Contractor-furnished and installed equipment.
 2. Drawings and calculations for TPF enclosure structural design in accordance with Section 34 31 89, TPF Enclosures.
 3. Composite full line diagrams of each TPS/SWS/PS power system.
 4. Substation enclosure equipment layout drawing showing final equipment locations including the routing of wireways and conduits.
 5. Connection (wiring) diagrams of each non-identical unit showing the following:
 - a. Terminal block arrangement, identifying each outgoing power and control terminal and showing interconnections between individual units and shipping splits of an equipment assembly.
 - b. Internal wiring diagrams of traction power transformers, autotransformers, switchgear cubicles and circuit breaker draw-out elements, power supply/battery chargers, and disconnect switch motor operators showing electrical devices in their relative physical locations, left to right and top to bottom. Each wire and jumper shall be shown on the wiring diagrams. Inboard wiring connected to these terminal blocks shall be positively identified and marked so as to be readily located at the device end.
 6. Wiring diagrams shall also comply with the following requirements:
 - a. Schematic or figurative type wiring diagrams which do not portray the physical wiring of the panels will not be accepted.
 - b. Wiring diagrams shall provide sufficient empty space next to terminal blocks for interconnecting wiring cable bundle numbers and individual wire color designations.
 - c. Wiring diagrams shall be orderly, legible and neat in appearance. Line crossings and drawing call-outs, if used, shall make use of different line widths or CAD line screening techniques to improve readability. Wiring diagrams that, in the opinion of Caltrain, do not meet this requirement, will be rejected.
 7. Contractor shall submit a document describing how to interpret the

- submitted wiring diagrams that includes at least one example of a wiring diagram and its associated schematic diagram.
8. Equipment nameplate schedules.
 9. Bills of material
 10. Protective device coordination curves in accordance with the following.
 - a. The Contractor shall submit graphic proof of protective device coordination of equipment furnished for each substation. Time-Current Coordination (TCC) curves shall be submitted on K & E type log-log paper showing full load currents, fault currents, and relay and fuse coordination for all 115 kV and 25 kV switchgear furnished, and for the substation auxiliary power system.
 - b. TCC curves shall show transformer damage curves and inrush curves, and cable damage curves in addition to the protective device curves. All curves shall be clearly identified on the TCC plots by descriptive text callouts; numeric identifiers alone will not be acceptable.
 - c. Traction power transformer and autotransformer overload capability at the 150 of full load current load levels shall be drawn on the submitted TCC curves. Adequate protective device coordination that permits these temporary overloads while protecting the transformers and power cables from damage shall be demonstrated on the TCC curves. Final coordination will be subject to Caltrain's approval.
 11. Outline drawings of battery charger, battery and battery rack; schematics and wiring diagrams of battery charger; battery and charger installation details and connection diagrams.
 12. 125 VDC distribution panel and substation low voltage AC distribution panel details and schedules.
 13. Equipment test procedures in accordance with Section 34 31 76, TPF Testing & Commissioning.
 14. Submittals of "As-Built" record drawings and other product record documents shall be in accordance with requirements set forth in Caltrain's project close out requirements.

1.16 CONTRACTOR'S DRAWINGS AND DOCUMENTS FOR APPROVAL

- A. Submittal drawings and documents shall be submitted in accordance with Special Provisions Section 01 33 00, Submittal Procedures.
- B. The content of each submittal shall be grouped by equipment, location, and/or other appropriate context such as to prevent reviews being conducted without relevant associated information also being provided.

PART 2 – PRODUCTS

2.01 WORKMANSHIP

- A. All surfaces of equipment shall be smooth and free of gaps, burrs, sharp edges, wrinkles, waves, blemishes, or other unsightly or unsafe defects which detract from a neat appearance of the finished product. Enclosing structures shall have sufficient structural reinforcement to ensure the surface shall remain plain and plumb, to restrain vibration, and to provide necessary strength and rigidity during shipping, installation, and operation with the specified seismic forces applied. Panel openings and mounting holes for instruments, relays, and control devices shall not distort the exposed finished surfaces.

2.02 ENCLOSURE AND FINISHES

- A. Equipment Metal Enclosures: Fabricate in accordance with the requirements given in the cited references listed in the Specifications.
- B. Surface Treatment:
 - 1. Finished Metal Surfaces: Exposed non-wearing metal surfaces shall be painted. Before painting, the metal surfaces shall be thoroughly cleaned and treated with rust inhibiting phosphatized coating. The metal finish shall be a semi-gloss paint system that is the manufacturer's standard for the service specified.
 - 2. Unfinished Metal Surfaces: Unfinished wearing metal surfaces shall be coated with layer of grease that is removable by a petroleum-derived solvent.
- C. Finish Color: Enclosures shall have an exterior finish of light gray color No. 61 or equal unless otherwise directed by Caltrain. Interior colors of enclosures shall be the manufacturer's standard for the intended service.
- D. Touchup: Sufficient finish coat touchup paint to cover five percent of the metal surfaces shall be furnished for each set of traction power equipment.

2.03 NAMEPLATES AND MARKINGS

- A. Standard Nameplates: Equipment standard nameplates shall comply with the requirements of the cited references given in the Specifications. Each item of substation equipment and associated control and metering devices shall be assigned an identification nameplate. The nameplates shall be opaque, white over black laminated melamine, not less than 3/32 inch thick. They shall have black engraved letters and comply with FS L-P-387, Type NDP. Equipment nameplates shall have 1-5/8-inch-high plates with 7/8-inch-high characters. Device nameplates shall have 5/8-inch-high plates and 1/4-inch-high characters. The nameplates shall be fastened to the equipment or device compartment door with machine screws.
- B. Special Nameplates
 - 1. Identification nameplates shall be provided for each item of traction power equipment, and associated control and metering devices.
 - 2. Nameplate Material: Opaque, white over black laminated, not less than 2.4 mm (3/32 inch) thick, black engraved letters and shall comply with FS L-P-387, Type NDP.
 - 3. Equipment Nameplates: 41 mm (1-5/8 inch) high plate with 22 mm

(7/8 inch) high characters.

4. Device Nameplates: 16 mm (5/8 inch) high plate with 6 mm (1/4 inch) high characters.
5. Nameplates shall be fastened to the equipment or device compartment door with machine screws.

2.04 WARNING SIGNS

- A. Warning signs shall be provided at traction power substation fencing, switching station fencing, paralleling station fencing, pre-packaged switchgear, pre-packaged control building and equipment enclosures, containing devices operating at over 600 V nominal.
- B. Warning signs shall be made of ASTM A167, Type 304L, stainless steel plate with red background and engraved white lettering of two inches' minimum height. The plate shall be 10 inches high by 14 inches wide and 1/8-inch-thick minimum, machine drilled to accept six tamperproof stainless steel machine screws, included, for attachment to vertical surface. Inscription shall read:

WARNING

HIGH-VOLTAGE

KEEP OUT

2.05 RELAYS, INSTRUMENTS, AND ACCESSORIES

- A. Relays:
 1. Relays shall be designed, constructed, and tested in accordance with the applicable provisions of ANSI C37.90 and EIA RS 443. Relay functional designations and circuits shall be as indicated on the Plans. The protection relay scheme shall meet the requirements of IEC 61850 to be addressable via the communications system.
 2. All protective relays of the solid-state type shall be semi-flush mounted, back-connected, adjustable. All incoming CT circuits shall have accessible shorting test switches.
 3. Protective relays shall have rustproof metal or high-impact plastic rectangular cases. Clapper type relays or auxiliary relays shall be mounted on a fixed portion of the structure.
 4. Microprocessor and numerical type relays approved by Caltrain are not required to be draw-out type.
 5. Lockout relays shall be hand-reset by black pistol-grip handle, complete with amber indicating LED rated 125 VDC. Light shall be connected so as to supervise the relay operating coil. Relays shall be furnished with independent contacts for use in tripping and close lockout of circuit breakers as indicated with one spare deck.
 6. Auxiliary relays shall be provided where required or specified. Auxiliary relays shall be front accessible and provided with dustproof cases. Relays not suitable for semi-flush mounting shall be surface mounted within the equipment control compartment. Relay contacts shall be

rated for the intended duty and meet the performance characteristics indicated.

7. Interposing relays for input/output interfaces with the SCADA equipment shall be plug-in style. Relays shall be UL-approved type.
8. Protective relay coordination curves and proposed settings, together with supporting calculations, shall be furnished by the Contractor for all equipment protective devices and systems for Caltrain review and approval.

B. Instruments and Meters:

1. Instruments shall be analog designed, constructed, and tested in accordance with the applicable provisions of ANSI C39.1.
2. Instruments shall be metal-case, semi-flush, for panel mounting. Instruments shall have 1 percent accuracy, taut-band suspension, and 250-degree scale, with black lettering on white background. Instrument scales shall be calibrated to match the primary circuit current and voltage ranges.
3. Watt-hour, Var-hour and Power Factor meters shall be single-phase, 3-wire, transformer-rated, 2.5 A, Class 20. Watt-hour demand meters shall have pointer-type primary reading kWh registers, and pointer-type kW demand indicator set for 30-minute interval. Meters shall be housed in rectangular, semi-flush, draw-out case.
4. Instruments and meters shall be wired through suitable test switches.

C. Accessories:

1. The control and indications available at the Central Control Facility will be replicated in each substation and connected to the substation communication network. The equipment controls will serve as backup to the computer controls. The following accessories will be provided based on this principle:
 - a. Control and selector switches shall be of the rotary type. Switches shall have silver-to-silver contacts rated at 20 A and cam action or similar positive means for actuating contacts. All switches shall have escutcheon plates.
 - b. Local control switches shall have heavy-duty pistol-grip handles and operation targets. Switch positions shall be TRIP-CLOSE with spring return to normal.
 - c. An illuminated GREEN LED shall indicate circuit breaker or switch in the OPEN position; RED shall indicate the CLOSED position.
 - d. LOCAL-REMOTE selector switches shall have oval handles. LOCAL-REMOTE selector switches shall have LOCAL-REMOTE positions and shall be provided with position indicating light. A WHITE indicating LED shall be provided which shall indicate when the switch is in the LOCAL position. A BLUE indicating LED shall be provided which shall indicate when the switch is

in the REMOTE position. Two separate isolated contacts shall be furnished for each control selector switch; one contact shall be used for local control annunciation and the other contact shall be used for remote supervisory control annunciation of LOCAL position, as indicated. Other required selector switches shall perform as specified.

- e. Thermostatically controlled space heater when required shall be provided in the quantity and capacity required to maintain the temperature/humidity inside the specified equipment enclosures above any anticipated dew point temperatures for the ambient conditions indicated. Space heaters shall be designed for continuous operation on 120 V, 60 Hz, single phase power supply.

PART 3 – EXECUTION

Refer to equipment sections for specific requirements.

END OF SECTION

SECTION 34 31 09

SUPERVISORY CONTROL INTERFACE TERMINAL CABINET

PART 1 – GENERAL

1.01 DESCRIPTION

- A. This Section specifies supervisory control interface terminal cabinets (IFTC) and accessories for a Traction Power Facility.
- B. The interface terminal cabinets shall provide the electrical interface between the traction power equipment and the supervisory control (SCADA). All necessary relays and transducers required for the supervisory control, status indication, remote trip annunciation, and analog indication shall be provided as part of this Contract.
- C. The Contractor shall integrate the SCADA system, Local Area Network (LAN), and interface terminal cabinet equipment to the extent necessary to provide an integrated, functional fiber optic interface to the Caltrain Central Control Facility (CCF), as well as local annunciation through a Human Machine Interface (HMI).
- D. For the Caltrain SCADA Point Count List of equipment control, indications, and analog points, see Appendix A, within Section 34 31 11 for a preliminary example. Final SCADA Point Count List for a location will be determined by the equipment supplied.
- E. Testing of the IFTC is specified in Section 34 31 76, TPF Testing and Commissioning.

1.02 RELATED SECTIONS

Related requirements are included in, but not limited to, the following Sections:

- A. 34 31 11 – Substation Supervisory Control and Data Acquisition (SCADA)
- B. 34 31 13 - Basic Traction Power Materials and Methods
- C. 34 31 29 - TPF Auxiliary Power Systems

1.03 REFERENCES

All equipment furnished under this Section shall be in accordance with the latest applicable standards of the IEEE, ANSI, NFPA, NEMA, ICEA, ASTM, UL, and National Electrical Code with regard to material, design, construction and testing. The standards applicable shall include, but not be limited to, the following:

- A. American National Standards Institute (ANSI):
 - 1. C37.90 - Relays and Relay Systems Associated with Electric Power Apparatus
- B. International Electrotechnical Commission (IEC):
 - 1. IEC 61850 - Communication Networks and Systems in Substations
- C. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE C37.90.1 Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
- D. National Electrical Manufacturers Association (NEMA):
 1. NEMA ICS-1 Industrial Control Systems General Requirements
 2. NEMA ICS-6 Industrial Control Systems: Enclosures
 3. NEMA 250 Enclosures for Electrical Equipment (1,000 Volts Maximum)
 4. NEMA WC-57 Standard for Control Cables

1.04 SUBMITTALS

Submit the following:

- A. Manufacturer's descriptive literature, catalog data and other pertinent information for all components sufficient to clearly demonstrate compliance with the Contract Documents.
- B. Detail drawings for the IFTC assembly. Drawings shall include dimensioned outline drawings of all major equipment and devices indicating their location relative to other equipment. Include dimensioned floor plan and front, rear, top, and section views. Cable routing shall be included on the IFTC drawings.
- C. Schematic wiring and internal connection diagrams showing all power and auxiliary circuits, protective devices, transducers, shunts, meters and contact development.

PART 2 – PRODUCTS

2.01 GENERAL

- A. Supervisory control interface requirements shall be as follows:
 1. Control: Provide one interposing relay for each function of a controllable device.
 2. Status Indication: Provide one auxiliary contact for each status of a device.
 3. Annunciation: Provide one auxiliary contact for each annunciation.
 4. Analog Status: Provide one transducer for each analog output.

2.02 ENCLOSURE

- A. Terminal cabinets shall be free standing, not less than No. 12 gauge sheet steel enclosures complying with NEMA ICS 6, Type 12 requirements. Cabinet shall be furnished with a hinged door complete with lockable handle and two-point latches, minimum.
- B. To provide compatibility with existing and future equipment, the enclosure shall be a Hoffman Engineering Company Catalog Number A-902420FS (NEMA 12 Single door) or equivalent design, and shall contain the following components:
 1. A-90RP25F5 – Full length angle kit

2. A-90RP24F6 – Half length angle kit
3. A-DB275 – Blower package
4. A-EXGR275 – Exhaust grill and filter
5. A-TEMNO – Temperature control switch
6. Power Distribution Strip:
 - a. 15A, 125 Vac, 1875W output rating
 - b. 1-U high with 8 outlets (4 front/ 4 rear)
 - c. Embossed power switch
 - d. Surge protected w/ surge LED

2.03 TERMINAL BLOCKS

- A. Terminal blocks shall be provided for every supervisory control, annunciation, status and analog indication. A minimum of 20 percent spare terminals shall also be provided.
- B. Terminal blocks shall be of the split or DIN rail type and mounted vertically. The arrangement shall permit easy termination of external field wiring for any future work by others to the supervisory control system.
- C. The terminal blocks shall accommodate #12 AWG to #24 AWG wire sizes.

2.04 INTERPOSING RELAYS

- A. Interposing relays shall be furnished, if necessary, to provide the input/output interface between the substation equipment and the supervisory control system.
- B. Interposing relays shall be plug-in, miniature-type, base-bracketed, or rack mounted. Relays shall be of one manufacturer, with minimum number of types to be fully interchangeable. Terminals of relay sockets shall be within the cabinet.
- C. Relay coils and contacts shall be rated in accordance with circuit function and operation, as specified in Section 34 31 13, Basic Traction Power Materials and Methods.

2.05 CONTROL SWITCHES AND TAGGING RELAYS

- A. Control switches, tagging relays and status indication lamps shall be furnished/installed on the mimic panel. Tagging Relays shall be Model # 93-23-DE as manufactured by Electros witch, GE or approved equal.

2.06 TRANSDUCERS

- A. Transducers shall be furnished in accordance with Section 34 31 13, Basic Traction Power Materials and Methods.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Install the specified Supervisory Control Interface Terminal Cabinet within each substation enclosure secure, plumb and level and in true alignment with related adjoining work.
- B. Install supporting members, fastenings, framing hangers, bracing, brackets, straps, bolts, and angles as required to set and rigidly connect the work.

END OF SECTION

SECTION 34 31 11

SUBSTATION SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA)

PART 1 – GENERAL

1.01 DESCRIPTION

- A. This section describes the requirements for the Substation Supervisory Control and Data Acquisition (SCADA) and automation equipment to be used at a Traction Power Substations (TPSS), Switching Stations (SWS), Paralleling Stations (PS), or Wayside Power Cubicles (WPC) located along the right of way. This Specification refers to these collectively as “substations”.
- B. The Substation SCADA system shall communicate with the Traction Power SCADA System (also referred to as the Headend or SCADA Office) located at the Central Control Facility and the Backup Central Control Facility. Traction power SCADA system is a system provided by others.
- C. Communications between the Substation SCADA and the Traction Power SCADA is provided by a fiber optic network described in the Division 27 specifications.
- D. Sample Substation SCADA System I/O Points are described in section 3.05 of this Specification.

1.02 RELATED SECTIONS

- A. Division 27 - Communications.
- B. Division 34 - Transportation:
 - 1. Section 34 31 03 - General Traction Power Requirements.
 - 2. Section 34 31 09 - Supervisory Control Interface Terminal Cabinet.

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), the International Electrotechnical Commission (IEC), National Fire Protection Association (NFPA), Institute of Electrical and Electronics Engineers (IEEE) Standards, National Standards Institute (ANSI), U.S. Department of Defense (USDOD) Standards, International Organization for Standardization (ISO) Standards and 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; and any applicable local ordinances.
- B. All equipment furnished under this section shall be in accordance with the applicable portions of the following standards:

1. ANSI C2 – National Electrical Safety Code.
2. ANSI–J-STD-607-A – Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications.
3. ANSI/HFES 100 – Human Factors Engineering Requirements for Visual Display Terminal (VDT) Work Stations.
4. ANSI/IEEE C37.90.2 – Standard for Tolerance of Radiated Electromagnetic Frequency Interference (RFI).
5. EIA-310 – Cabinets, Racks, Panels, and Associated Equipment.
6. IEC 654-3 – Operating Conditions for Industrial Process Measurement and Control Equipment – Mechanical Influences.
7. IEC 60617 – Graphic Symbols for Diagrams.
8. IEC 61850 – Communication Networks and Systems in Substations.
9. IEEE C37.1 – Definition, Specification, and Analysis of Systems Used for Supervisory, Data Acquisition, and Automatic Control.
10. IEEE C37.2 – Electrical Power System Device Functional Numbers, Acronyms, and Contact Designations.
11. IEEE C37.90.2-2012 - Standard for Tolerance of Radiated Electromagnetic Frequency (RFI).
12. IEEE C62.41 – Guide for Surge Voltages in Low-Voltage AC Power Circuits.
13. IEEE 730 – Software Quality Assurance Plans.
14. IEEE 828 - Standard for Software Configuration Management Plans.
15. IEEE 829 – Software Test Documentation
16. IEEE 1815-2012 – Standard for Electric Power Systems Communications-Distributed Network Protocol (DNP3).
17. ISO/IEC 12207 – Systems and software engineering -- Software life cycle processes.
18. NEMA FB-1 – Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies.
19. NFPA 70 – National Electrical Code (NEC).
20. NFPA 75 – Protection of Electronic Computer / Data Processing.
21. NFPA 130 – Standard for Fixed Guideway Transit and Passenger Rail Systems.

22. OSHA 29 CFR 1910 – Safety and Health Standards.
23. UL 1778 – Uninterruptible Power Supply Equipment.

1.04 DESIGN SUBMITTALS

- A. Any work without prior Caltrain action on the relevant plans and procedures in accordance with defined review processes will be undertaken at the Contractor's risk.
- B. 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, final design, installation, testing, and maintenance of the Substation SCADA. Plans shall include:
 1. Software Quality Assurance Plan, in accordance with IEEE Standard 730.
 2. System Description: Submit complete written and graphic description of how the Substation SCADA operates, including system and command software, sequences, and application programs. Provide complete communication software protocol data.
 3. Hardware Documentation: Submit complete written and graphic description of how the hardware is installed and functions to provide a complete operable system, as specified.
 - a. Shop drawings shall include overall system configuration drawings, system interconnection wiring diagrams, installation details and I/O termination assignments and details. Shop drawings and design submittals shall include any CADD files in AutoCAD formats. Drawings shall conform to the Caltrain CADD standards. All interconnections to the shop drawings shall show all wiring and labels that enter and exit a terminal block.
 - b. Product data sheets shall be provided for all hardware furnished or provided.
 - c. Environmental and utility requirements shall be identified for each installation location in a specific submittal identifying the required installation and operating environment, space cooling or heating, data communications infrastructure, electrical power and grounding connections. Include in this submittal a listing of any environmental/utility deficiencies noted in review of the contract documents and/or site inspection.
 4. Test Plans and Procedures: Submit test plans and procedures in accordance with IEEE Standard 829 for all tests required by the Software Quality Assurance Plan.
 5. Test Results Documentation: Submit test results documentation in accordance with IEEE Standard 829.

6. Training Data: Submit training manuals and instructions manuals, as specified in Section 34 31 93 TPF Energization Testing and Training.

1.05 CONSTRUCTION SUBMITTALS

- A. As part of the Site Specific Work Plan submission for Caltrain's action in accordance with the project review process, prepare and submit a detailed Construction Sequencing Plan for each location where a Substation SCADA is to be installed, only required when more than two locations will be installed.
- B. Submit drawings indicating any required modifications to new systems 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 Caltrain's action in accordance with the project review process a minimum of 30 days prior to the scheduled cutover.
- C. Request Caltrain's action in accordance with the review process for the project prior to making any deviation, modification, or changes to submitted design drawings returned with a approval. During the field testing/cut-over period, obtain the Caltrain's action in accordance with the review process for the project by the Caltrain's representative for any deviations, changes, or modification to the design drawings.

1.06 DELIVERABLES

- A. Submit drawings, schematics, reports, and all other information necessary to define the Basis of Design, and Design Submittals based on the projects contract requirements.
- B. Submit manufacturers' warranties, instruction sheets, and part lists supplied with materials to Caltrain for Caltrain's action in accordance with the review process for the project.
- C. Operation and Maintenance Manuals: A minimum of 30 days prior to placing any system in- service, submit to Caltrain a set of application, installation, operating, and maintenance manuals of all new equipment and systems utilized under this Contract. Include complete material ordering reference numbers for each type of product.
- D. Contractor shall provide all necessary software and cabling required to communicate with the material delivered in accordance with Section 34 31 11. In the event of any software paid licenses, the contractor will provide a minimum of 2 licenses to Caltrain.

1.07 AS-BUILT DOCUMENTATION

- A. The following as-built documentation requirements augment requirements specified in accordance to the projects review process. Submit as- built documentation within 45 days of a site placed in service.
- B. The final as-built drawings shall be 11 inches by 17 inches, unless authorized by Caltrain to substitute another size.

PART 2 – PRODUCTS

2.01 SYSTEM DESCRIPTION

- A. The Substation SCADA shall be delivered with each Traction Power Substations (TPSS), Switching Stations (SWS), Paralleling Stations (PS), and Wayside Power Cubicles (WPC) being delivered.
- B. The major components of a Substation SCADA are: Substation Gateway (sometimes called the data concentrator), Intelligent Electronic Devices (IED), Remote Terminal Unit (RTU), Human Machine Interface (HMI), and the Substation LAN.
- C. The Substation SCADA shall interface with substation automation equipment, electrical power equipment, and protective relaying in order to provide real time information to the Power Director and to provide the means by which the Power Director can control the components of the traction power system. These controls shall include circuit breakers (CB), and motor operated disconnect (MOD) switches and tagging relays. In addition to collecting traction power system data, the substation SCADA system shall also collect data and alarms from other substation support equipment including HVAC, intrusion, CCTV, and fire alarm systems.

2.02 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 the same as in section 34 31 03 – General Traction Power Requirements.
 - 1. General:
 - a. Seismic Zone Location of Work Site: Seismic Zone 4 as defined in the Uniform Building Code.
 - b. Vibrations of Class V.S.3, per IEC 60068-2-6.
 - 2. Indoor environments:
 - a. Temperature range: From 0°C to 60°C.
 - b. Relative humidity range: From 5% to 95% non-condensing.

2.03 EQUIPMENT – GENERAL

- A. All materials and equipment shall be the products of manufacturers regularly engaged in the production of such material and equipment. The materials and equipment shall have shown proven performance in North America for a minimum of 5 years.
- B. Alternate equipment equal to or exceeding the specifications and requirements may be used subject to Caltrain's action in accordance with the approval process

defined for the project. Should alternate equipment be provided, the Contractor shall perform all necessary work to fit the alternate equipment to these specifications at no additional cost to the Caltrain.

- C. The Substation SCADA shall have open system architecture to connect multi-vendor products.
- D. The Substation SCADA shall exhibit an availability of 99.99% measured over any 120-day period. If a non-redundant architecture is supplied, The Substation SCADA design shall emphasize self-diagnosis, limiting the scope of component failures, and rapid replacement of failed components.

2.04 SUBSTATION GATEWAY

- A. The Substation Gateway shall be ABB MicroSCADA Pro SYS600C Data Concentrator and Gateway, or approved equal, and shall meet the following minimum requirements:
 - 1. Communicate with RTUs and IEDs to monitor and control substation equipment over the Substation LAN (Local Area Network) using the IEC 61850 protocol. Gateway functions at WPCs shall be performed by the local RTU located at WPC facility.
 - 2. Collect and store data from connected substation devices. The database shall contain all of the data available in all IEDs and RTUs on the substation LAN. The database shall be provided with 20% unassigned designators and values to facilitate changes during commissioning.
 - 3. Transmit data to the Traction Power SCADA on a demand (polled) basis.
 - a. All status (discrete) data at a substation shall be requested and reported no more frequently than every 1 second.
 - b. All analog data at a substation shall be requested and reported no more frequently than every 2 seconds.
 - 4. Transmit change of state information to the Traction Power SCADA System on an exception (when changed) basis and on a polled basis. The SCADA communication system shall be able to achieve the following communication timing:
 - a. The Substation SCADA shall support periodic polls for data from the Traction Power SCADA.
 - b. Analog measurements reported to the Traction Power SCADA shall be current to within 1.0 seconds.
 - c. The status (discrete) data state changes reported to the Traction Power SCADA shall be current to within 0.5 seconds.
 - d. The timestamps of simultaneous alarms and events occurring at multiple substations shall be coincident to within 10 ms.

- e. Status (discrete) data state changes shall be time-stamped to a resolution of 1 ms (where supported by the input interface devices – IEDs or other device).
- 5. Include an internal clock synchronized to the time information derived from the Global Positioning System. The clock shall be in 24 hour format to a 1 millisecond resolution: HH:MM:SS.SSS. When disconnected from the GPS, the clock shall maintain a ± 1 ms accuracy over 24 hours.
- 6. Maintain an event log that includes a time stamp derived from the Global Positioning System. The event log shall include all change of state information and all user actions entered through the HMI.
- 7. Perform calculations and Boolean equations based on algorithms pre-determined by authorized users.
- 8. Permit logical interaction between IEDs to achieve enhanced relay protection based on pre-determined programming.
- 9. Communicate with the Traction Power SCADA System over the TPF/WPC SCADA Control VLAN using the DNP3 TCP/UDP with secure authentication protocol version "V2" (DNP3-SA v2) compliant with IEEE 1815-2012.
- 10. Provide access for maintenance and engineering personnel to the Substation equipment over the TPF HMI WAN.
- 11. Operate in "remote" and "local" modes.
 - a. Under remote operation, the Substation Gateway shall accept and respond to commands originating from the Traction Power SCADA System. The Substation Gateway shall allow a local operator to observe operations, but shall not allow the local operator to initiate operation of any substation equipment.
 - b. The HMI shall allow a local operator to initiate a local mode request. Having satisfied security controls and having received authorization, the local operator shall have the ability to assume control of all substation equipment. Local control shall not reset or bypass any existing tags. The Local control shall not alter ongoing recording, logging, alarm annunciation, or data reporting functions. The Traction Power SCADA shall not be able to override local control.
 - c. Only at a WPC location, the HMIs will not be used in a local mode for sending commands to the field. All onsite controls that must be performed will use the SCITC control handles when physically placed in local.
- B. The Substation Gateway shall be powered at 125 volts DC.
- C. The Substation Gateway shall automatically restart when input power is restored after loss of operating power. During the automatic restart process the

Substation Gateway shall not initiate any action that may change the operating state of the traction power system. During the restart process the Substation Gateway shall notify the Traction Power SCADA that it is returning to operation. During the restart process the Substation Gateway shall identify any inconsistencies between the contents of the last known database and the present system configuration. The Substation gateway shall notify the Traction Power SCADA of the inconsistencies and await corrective action. All other functionalities shall also restart into a safe mode; but shall not initiate any control actions unless authorized by a user.

2.05 HMI REQUIREMENTS

- A. Each Substation Gateway and at each WPC site shall drive local and remote Human Machine Interface devices.
 - 1. The HMI shall be based on the Microsoft Windows 11 or higher operating system. The selected operating system must provide the agency with access to security updates for a minimum of 7 years after the final acceptance to avoid operating systems that are obsolete or reached their end of life.
 - 2. Substation HMI shall be a rack-mount, slide-out design, with a minimum screen diagonal of 19 inches and a minimum 1600 x 1200 resolution.
- B. The HMI shall provide for the following capabilities:
 - 1. Display a dynamic graphic of the local substation equipment and the local MOD switches. The graphic shall present all available power system data from all substation devices.
 - a. Graphics displayed to the user shall be based on the current implementation by Caltrain.
 - 2. Display the local event list.
 - 3. Display the current database, all stored files and oscillographic records.
 - 4. Confirm communications with the Traction Power SCADA System.
 - 5. Observe the databases, displays and logs of the other substations and WPCs via Remote Desktop.
 - 6. Alter IED settings. This action shall require special security controls including authorized user authentication and shall be recorded as an event.
 - 7. Provide an HMI option to place the substation in Local mode. This action shall require security controls including authorized user authentication and shall be recorded as an event.
 - 8. Enable or disable and modify any input or output.
 - 9. Read error messages generated by the Substation Gateway, IEDs, and

RTU.

10. The HMI interface shall support a Remote Desktop web interface for users located outside the substation that provides a graphic presentation similar to the local HMI.
 11. The HMI at any substation or WPC shall be able to connect to and interact with the interface at any other substations or WPC (assuming a suitable communications path and proper permissions) via Remote Desktop web interface. HTTP is not currently used.
- C. The content and format of the HMI displays shall use Caltrain standard symbols and layout. Final content and format of the HMI shall be submitted to Caltrain's action in accordance with the approval process for the project.

2.06 INTELLIGENT ELECTRONIC DEVICES (IEDs)

- A. IEDs are a class of substation automation equipment that provide measurement processing, protective relaying, and SCADA communications functionality. IEDs shall be used to monitor and record the utility power source; to protect and monitor the transformers; to protect and monitor the HV and MV circuit breakers and to monitor the bus currents and OCS voltages. The IEDs shall be connected to the traction power equipment using industry conventional instrument transformers (Section 34 31 43).
- B. The IEDs shall provide equipment protection following industry standard conventions, designations and nomenclature as described in IEC 60617 and IEEE C37.2. At a minimum the IEDs shall be capable of performing the following functions as appropriate to their application:
1. #21, distance relay.
 2. #26Q, transformer liquid temperature.
 3. #27, under voltage.
 4. #49, over temperature.
 5. #49CAT, catenary over temperature.
 6. #49T, transformer over temperature.
 7. #50/27, close-in fault.
 8. #50/51, overcurrent Instantaneous.
 9. #50BF, breaker failure.
 10. #51, inverse time overcurrent.
 11. #59, over voltage.
 12. #63, transformer sudden pressure.

13. #71q, transformer oil.
 14. #79, recloser.
 15. #86, lock-out/ tag-out.
 16. #87, autotransformer differential.
 17. #87b, bus differential.
 18. #87t, transformer differential.
- C. IEDs shall be selected to provide the required functions and combination of functions and then programmed to execute the desired functions. Refer to the traction power system specification and drawings for detailed requirements.
- D. The IED shall be ABB Relion® 670 Series or Siemens Siprotec 7ST61 or Siemens Siprotec 7SJ62, or approved equal, and support SCADA functionality:
1. Transmitting voltage and current values to the Substation Gateway.
 2. Transmitting status data to the Substation Gateway.
 3. Calculating additional variables using standard calculations for watts, vars, power factor, harmonic distortion, watt hours, peak demand, average demand and projected demand and transmitting the variables to the Substations Gateway.
- E. IEDs shall communicate with the Substation Gateway over the Substation LAN using the IEC 61850 protocol. All data collected and calculated by the IED shall be transferred to the Substation Gateway.
1. IEDs shall also support transmission and receipt of GOOSE messages.
 2. IEDs shall also allow engineering and maintenance personnel to adjust, alter, and reprogram the IED from the HMI via the Substation Gateway or from any HMI at another location on the SCADA WAN also via the Substation Gateway after satisfying security controls.
- F. IEDs shall be powered at 125 volts DC.
- G. IEDs shall automatically restart when input power is restored after loss of operating power. During the automatic restart process an IED shall not initiate any action that may change the operating state of the traction power system.
- H. IEDs shall automatically push any COMTRADE files and logs from the relay to the local HMI for storage and access.

2.07 REMOTE TERMINAL UNIT (RTU)

- A. The RTU shall be ABB RTU500 Series communication units, input and output extension modules, and DC power supplies.

- B. The RTUs shall serve as the primary means to monitor status (contact) conditions and to drive binary control outputs.
 - 1. The installed quantity shall be 25% greater than the required quantity. The system design shall permit a 100% increase of inputs and outputs with the addition of new hardware.
 - 2. For each card type used in the RTU, spare cards equal to 10 % of the quantity supplied, or a minimum of two cards per type—whichever is greater—shall be included in the delivery.
- C. RTUs shall communicate with the Substation Gateway over the Substation LAN (Local Area Network) using the IEC 61850 protocol. RTUs in WPCs communicate directly with the TPSS SCADA using DNP 3 protocol.
- D. RTUs shall be powered at 125 volts DC.
- E. RTUs shall automatically restart when input power is restored after loss of operating power. During the automatic restart process an RTU shall not initiate any action that may change the operating state of the traction power system.

2.08 ENCLOSURES

- A. All Substation SCADA equipment shall be mounted in enclosures. The enclosures shall be as described in Section 34 31 09, Supervisory Control Interface Terminal Cabinet.
 - 1. Install all system components and appurtenances in accordance with the manufacturer's recommendations, documentation and instructions.

PART 3 – EXECUTION

3.01 GENERAL REQUIREMENTS

- A. Installation:
 - 1. The Contractor shall install the SCADA equipment at the required TPSS, SWS, PS or WPC location.
 - 2. Install all system components and appurtenances in accordance with the manufacturer's recommendations, documentation and instructions.
 - 3. Provide complete documentation of all necessary interconnections, services, and adjustments required for a complete operable system.
 - 4. Furnish, and install electrical devices, sensor wiring, control wiring, data communication links and conduit, as required.
 - 5. Furnish all additional devices as required for complete operation.

3.02 MAINTENANCE AND SERVICE

- A. General Requirements:
 - 1. Provide all services, materials, and equipment necessary for the successful

operation of the entire system and all appurtenances for a period of 1 year after acceptance by Caltrain. System acceptance shall be defined as specified.

2. Provide Virtual Private Network (VPN) capability for on-line support diagnostics by the Contractor.

3.03 OPERATING PERSONNEL TRAINING

- A. Conduct training at the job site (or other space furnished by Caltrain) for a period of 5 days minimum. A training day is defined as 8 hours of instruction, Monday through Friday, including 2, 15-minute breaks, and excluding lunch time. The training days shall be in accordance with a schedule set up by Caltrain. Train operating personnel in the functional operation of the system installed and the procedures that they will employ for system operation, maintenance, and repair. Train Engineering personnel in the creation and modification of databases for the RTU, HMI, and any other systems delivered under this section.
- B. Provide a qualified instructor to teach operating personnel the operation, adjustment and maintenance of the equipment and system. Provide a qualified instructor to teach Engineering personnel the operation, adjustment and maintenance of the equipment and system to allow for modification of the various databases and configurations.
- C. Orient the training specifically to the system installed. Provide training manuals which describe in detail the hardware, software and operation of the particular SCADA system provided. Provide all equipment and materials required for classroom training. Provide instructor materials, including lesson plans and supporting data, to support future training by Caltrain personnel.

3.04 TESTING AND SYSTEM ACCEPTANCE

- A. Test Documents: All test documents, including all plans, procedures, and results reports shall be subject to Caltrain's action in accordance with the project's review process.
- B. Factory Acceptance Test:
 1. Prior to shipment of any equipment, fully assemble the Substation SCADA at the manufacturer's factory. Testing shall unambiguously demonstrate that the operation and performance of the system satisfies the requirements of these specifications. Testing shall be based on equipment test plan and procedures. Only upon successful completion of the preliminary equipment test witnessed by Caltrain may the equipment be shipped to the job site and installed. The test shall include the following:
 - a. Operator interactions with the operator color graphic user interface, including all the specific job graphics.
 - b. Demonstration of a digital on-off sequence and an analog point monitoring program. Use actual outputs and inputs with

simulated field equipment. Program coding and editing shall be demonstrated. Actual programs with tag names developed for this project.

- c. Demonstration of override control of outputs.
- d. Demonstration of event recording.
- e. Demonstration of data transfer for control and status feedback.
- f. Demonstration of switchover for all redundant systems and components.
- g. Demonstration of data transfer for control and status feedback.
- h. All output control, input status, and analog inputs will be demonstrated to show wiring and database match the built system, to the extent possible at the factory.

C. Site Acceptance Test:

1. Prior to initiating Site Acceptance Testing, the Contractor shall verify that the system's performance fully complies with the requirements specified in this document. The Contractor is responsible for implementing any necessary modifications to achieve full conformance with these specifications. Upon successful verification of compliance, the Contractor may formally notify Caltrain to schedule the Site Acceptance Testing. Caltrain will participate in this testing as a field witness and operator from the headend system.
2. Site Acceptance Testing shall consist of a preliminary test, a system timing test, and a point test. All test forms must be submitted to Caltrain for review and approval no later than 10 days prior to the commencement of Site Acceptance Testing.
3. Preliminary System Test:
 - a. Program backup and program load operation
 - b. Startup and diagnostics.
 - c. Traction Power SCADA communication status
 - d. Automatic restart after power failure
 - e. Switchover of all redundant system and components.
4. System Timing Test:
 - a. Demonstrate end-to-end system timing. This test shall demonstrate display update times, database update times, and supervisory control times under full operational conditions.
5. Point Test: During Point Testing, control operations will be conducted from the Human-Machine Interface (HMI) and the headend system to the field device. If equipment operation is not feasible, all metering for

control confirmation and indication will be performed at the terminal block closest to the final piece of equipment.

Caltrain reserves the right to perform testing on the final equipment once it becomes available, prior to accepting any test results. If more than five failures are identified by Caltrain during testing, the testing will be halted. The contractor will then be required to perform all necessary diagnostics and corrective actions to ensure the success of the next scheduled test.

The earliest a retest may be scheduled is five days after the failed test, unless Caltrain grants an exception.

- a. Prepare a printed form that includes all items listed in the I/O Points List. This form will be utilized during the testing process for each point. Testing shall be conducted on both the primary and secondary sides of the unit to verify proper indication and control from the headend system and the Human-Machine Interface (HMI).
 - b. A logic test will be conducted to verify the proper functionality and sequencing of programmed events. All logic programmed into the units will be clearly documented, including the expected inputs and corresponding outputs for each test. Each logic sequence will be evaluated, and the outcome will be recorded as either a pass or fail based on the test results.
6. Test Report: A Site Acceptance Test report will be provided within 5 days of completion.
- D. System Integration Test: Once Site Acceptance Testing has been completed and equipment is operational, the System Integration Test can be scheduled with Caltrain.
1. The system shall operate in its normal mode, continuously for a 30 day endurance test. The system shall operate satisfactorily with no failures during 30 days of continuous operation.
 2. At the end of the 30 day endurance test period, the Contractor shall submit a test report. The test report, which shall include a copy of entries to the bound log, shall document any failures including the time of occurrence, established cause of the failure, corrective action, and time of restoration to satisfactory operation. Any failure shall require the endurance test to be conducted for another 30 days of continuous operation, except the following failures which are excluded:
 - a. Failure of an input power source.
 - b. Failure of Caltrain-provided equipment.
 - c. A cable cut not caused by the Contractor.
 3. At the end of the second 30 day test period (if required), the Contractor shall submit a test report, as specified. Any failure (other than specified

exclusions) shall require one of the following, at Caltrain’s sole discretion:

- a. Items of work which have experienced failures will be replaced by the Contractor at no additional cost to Caltrain, and the endurance test will be conducted for another 30 days of continuous operation.
 - b. Replacement or alternate products shall be proposed by the Contractor at no additional cost to Caltrain. If accepted by Caltrain, the replacement products furnished by the Contractor shall be installed and the endurance test will be conducted for another 30 days of continuous operation.
 - c. The endurance test shall be conducted on a rolling 30 day period.
4. The endurance test shall be satisfactorily concluded when a 30 day test period of continuous operation has been completed with no failures (other than specified exclusions) and Caltrain has reviewed and accepted the test report. A system not in compliance with these specifications shall be unsatisfactory. Additionally, any system that has not satisfactorily completed the endurance test after 120 days of testing will be considered unacceptable to Caltrain.
- E. Acceptance: The SCADA system will be accepted after Caltrain accepts the test report documenting satisfactory completion of the endurance test and corrections to any system deficiencies and verifies that training, submission of record documents and manuals, and delivery of source code are complete.

3.05 EQUIPMENT POINT LISTING

- 1. WPCs will have the following points available at each location. The number of final number of inputs and outputs will be based on the final approved design.

Location Type	Point Type	Object Text	Event Text
WPC	BI	LOSS OF AC - 27AC	NORMAL/ALARM
WPC	BI	LOSS OF DC - 27DC	NORMAL/ALARM
WPC	BI	MAN TRANSFER SW NORMAL	ALARM/NORMAL
WPC	BI	MAN TRANSFER SW EMERGENCY	NORMAL/ALARM
WPC	BI	LOSS POWER SUPPRESSOR	NORMAL/ALARM
WPC	BI	LOSS OF ABB 24VDC	NORMAL/ALARM
WPC	BI	GND DETECT	NORMAL/ALARM
WPC	BI	CHARGER AC IN FAIL	NORMAL/ALARM
WPC	BI	CHARGER DC OUT FAIL	NORMAL/ALARM
WPC	BI	LOW DC VOLTS	NORMAL/ALARM
WPC	BI	CHARGER DISCONNECT SW	OPEN/CLOSED
WPC	BI	HVAC DIRTY FILTER	NORMAL/ALARM
WPC	BI	HIGH TEMP ALARM	NORMAL/ALARM

WPC	BI	HVAC FAILURE ALARM RELAY	NORMAL/ALARM
WPC	BO	HVAC UNIT SHUTDOWN	
WPC	BI	FIRE PANEL ALARM	NORMAL/ALARM
WPC	BI	FIRE PANEL TROUBLE	ALARM/NORMAL
WPC	BI	FIRE PANEL SUPERVISORY	ALARM/NORMAL
WPC	BI	WAN SWITCH 1 TROUBLE	NORMAL/ALARM
WPC	BI	WAN SWITCH 2 TROUBLE	NORMAL/ALARM
WPC	BI	LAN POE SWITCH TROUBLE	NORMAL/ALARM
WPC	BI	BUILDING INTRUSION	ALARM/NORMAL
WPC	DB	STATION CONTROL (43)	INTERMEDIATE/LOCAL/REMOTE/FAULTY
WPC	BI	INPUT FAULTY	NORMAL/ALARM
WPC	BI	OUTPUT FAULTY	NORMAL/ALARM
WPC	BI	RTU FAULTY	NORMAL/ALARM
WPC	BI	NOT SYNCHRONIZED	NORMAL/ALARM
WPC	DB	MOD ###	INTERMEDIATE/OPEN/CLOSED/FAULTY
WPC	DB	MOD ### 86TG	INTERMEDIATE/APPLIED/RELEASED/FAULTY
WPC	BI	MOD ### LOSS CONTROL VOLTAGE	NORMAL/ALARM
WPC	BO	MOD ### OPEN	
WPC	BO	MOD ### CLOSE	
WPC	BO	MOD ### 86TG RELEASE	
WPC	BO	MOD ### 86TG APPLY	

2. The PS, SWS, and TPSS can be provided for the in-service stations upon request.

END OF SECTION

SECTION 34 31 13

BASIC TRACTION POWER MATERIALS AND METHODS

PART 1 – GENERAL

1.01 SCOPE

- A. This Section includes specifications for the basic materials and methods for traction power-related electrical work specified in detail in other sections of the traction power Specifications. Requirements contained in the other sections shall prevail over this Section 34 31 13, in cases of conflict.
- B. The Work of this Section consists of providing the following basic electrical materials and equipment:
1. PVC Conduit, Fittings, and Spacers.
 2. Galvanized Rigid Steel (GRS) Conduit and Accessories
 3. Reinforced Thermosetting Resin Conduit (RTRC) and Accessories
 4. Conduit Expansion and Deflection Fittings
 5. Steel Cable Trays and Fittings
 6. Fiberglass Cable Trays
 7. Aluminum Cable Trays
 8. High Density Polymer Concrete Trench
 9. Metal Framing and Wireways
 10. Hangers and Supports
 11. Concrete Inserts
 12. Outlet, Junction, and Pull Boxes
 13. Wiring Devices
 14. Warning Signs
- C. Electrical components specified in this Section shall be fully integrated with equipment in the related Sections, and work shall include all operations necessary to furnish, install, test, adjust and put into satisfactory operation all electrical equipment and systems shown on the Contract Drawings and/or specified in the related Sections.

1.02 REFERENCE STANDARDS

- A. American National Standards Institute (ANSI):
 - 1. B1.1 Unified Inch Screw Threads (UN and UNR Thread Form)
 - 2. B1.13 M Metric Screw Threads – M Profile
 - 3. C2 National Electrical Safety Code
 - 4. C80.1 Rigid Steel Conduit, Zinc Coated
 - 5. C82.1 Electric Lamp Ballast-Line Frequency Fluorescent Lamps Ballast

- B. American Society for Testing and Materials (ASTM):
 - 1. A36/A36M Carbon Structural Steel
 - 2. A48 Gray Iron Castings
 - 3. A108 Steel Bars, Carbon, Cold-Finished, Standard Quality
 - 4. A123 Zinc (Hot-Dip Galvanized) Coatings for Iron and Steel Products
 - 5. A153 Zinc Coating (Hot-Dip) on Iron and Steel Hardware
 - 6. A167 Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
 - 7. A569 Steel, Carbon (0.15 Maximum, Percent) Hot Rolled Sheet and Strip Commercial Quality
 - 8. A575 Steel Bars, Carbon, Merchant Quality, M-Grades
 - 9. A576 Steel Bars, Carbon, Hot-Wrought, Special Quality
 - 10. B1 Hard-Drawn Copper Wire
 - 11. B2 Medium Hard-Drawn Copper Wire
 - 12. B3 Tinned Soft or Annealed Copper Wire
 - 13. B187 Copper Bus Bar, Rod, and Shapes
 - 14. B633 Electrodeposited Coatings of Zinc on Iron and Steel
 - 15. D149 Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
 - 16. D570 Water Absorption of Plastics
 - 17. D635 Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position
 - 18. D638 Tensile Properties of Plastics

19. D695 Compressive Properties of Rigid Plastics
 20. D790 Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
 21. D1248 Polyethylene Plastics Extrusion Materials for Wire and Cable
 22. D2000 Classification System for Rubber Products in Automotive Applications (SAE J200)
 23. D2240 Rubber Property – Durometer Hardness
 24. D2802 Ozone-Resistant Ethylene-Alkene Polymer Insulation for Wire and Cable
 25. E84 Surface Burning Characteristics of Building Materials
 26. F512 Standard Specification for Smooth-Wall PVC Conduit and Fittings for Underground Installation
- C. Federal Specifications (FS):
1. A-A-1923A Shield, Expansion (Lag, Machine and Externally Threaded Wedge Bolt Anchors)
 2. A-A-1925A Shield, Expansion (Nail Anchors)
 3. FF-B-588D Bolt, Toggle; and Expansion Sleeve, Screw
 4. FF-S-325 Shield, Expansion; Nail Expansion; and Nail, Drive Screw (Devices, Anchoring, Masonry)
 5. L-P-387A Plastic Sheet, Laminated, Thermosetting (For Designation Plates)
 6. W-F-408E Fittings for Conduit, Metal, Rigid (Thick Wall and Thin Wall (EMT) Type)
- D. National Electrical Manufacturers Association (NEMA):
1. 250 Enclosures for Electrical Equipment (1,000 Volts Maximum)
 2. AB 1 Molded Case Circuit Breakers and Molded Case Switches
 3. FB 1 Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies
 4. FG 1 Fiberglass Cable Tray Systems
 5. ICS 4 Industrial Control and Systems: Terminal Blocks
 6. ICS 6 Industrial Control and Systems: Enclosures

7. RN1 Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
 8. TC 2 Electrical Polyvinyl Chloride (PVC) Tubing and Conduit
 9. TC 3 PVC Fittings for use with Rigid PVC Conduit and Tubing
 10. TC 9 Fittings for PVC Plastic Utilities Duct for Underground Installation
 11. TC 14 Reinforced Thermosetting Resin Conduit (RTRC) and Fittings
 12. VE 1 Metallic Cable Tray Systems
 13. WD 1 General Color Requirements for Wiring Devices
- E. National Fire Protection Association (NFPA):
1. 70 National Electrical Code (NEC)
- F. Underwriters Laboratories, Inc. (UL):
1. 5 Surface Metal Raceways and Fittings
 2. 6 Rigid Metal Conduit
 3. 20 General Use Snap Switches
 4. 50 Enclosures for Electrical Equipment
 5. 489 Molded-Case Circuit Breakers, Molded Case Switches and Circuit-Breaker Enclosures
 6. 498 Attachment Plugs and Receptacles
 7. 506 Specialty Transformers
 8. 542 Lampholders, Starters and Starter Holders for Fluorescent Lamps
 9. 651 Schedule 40 and 80 Rigid PVC Conduit
 10. 870 Wireways, Auxiliary Gutters and Associated Fittings
 11. 924 Emergency Lighting and Power Equipment
 12. 935 Fluorescent Lamp Ballasts
 13. 1059 Terminal Blocks
 14. 1570 Fluorescent Lighting Fixtures
 15. 1581 Reference Standard for Electrical Wires, Cables and Flexible Cords
- G. European Standards (EN):

1. EN 50121-5 Railway applications. Electromagnetic compatibility. Emission and Immunity of Fixed Power Supply and Apparatus
2. EN 50160 Voltage Characteristics of Electricity Supplied by Public Distribution Systems
3. 6100-6-4 Electromagnetic Compatibility – Emission Standards for Industrial Environments

1.03 RELATED SECTIONS

- A. Reference is made, but is not limited to, the following Sections:
1. 34 31 03 - General Traction Power Requirements
 2. 34 31 11 - Substation Supervisory Control and Data Acquisition (SCADA)
 2. 34 31 39 - Control and Indication Panels
 3. 34 31 16 - TPF Grounding and Bonding
 4. 34 31 69 - TPF Exterior Lighting and Lightning Protection

1.04 SUBMITTALS AND INFORMATION TO BE PROVIDED

- A. Submittal shall be in accordance with the requirements of Section 34 31 03, except as modified herein.
- B. Submit Product Data for all items provided under this Section, including, but not limited to, the following:
1. Product data for each type and manufacturer of conduit, raceway, flexible metal conduit, conduit fitting, box, and all incidental material to be provided and installed.
 2. Product data for each type of box or enclosure to be provided.
 3. Product data for each size and type of cable tray, fitting and support to be provided.
 4. Product data for the following items for raceway, cable tray, and equipment supports:
 - a. Concrete expansion anchors.
 - b. Channel system, including clamps and fittings.

PART 2 – PRODUCTS

2.01 GENERAL

- A. Materials furnished shall be standard products of manufacturers regularly engaged in the production of the materials specified and shall be Listed.

2.02 GALVANIZED RIGID STEEL CONDUIT (GRS)

- A. Conduits, Couplings, Elbows, Bends and Nipples: ANSI C80.1 and UL 6.
- B. Conduit Fittings and Accessories: FS W-F-408, galvanized steel.
 - 1. Conduit Hubs: Watertight, as required, with neoprene gasket, nylon insulated throat and bonding locknut.
 - 2. Grounding: Nylon insulated metal bushing.
- C. Conduit Straps, Clamps, Backs and Spacers – Hot-dip galvanized malleable iron.

2.03 PVC CONDUIT, FITTINGS, AND SPACERS

- A. Conduits: Comply with NEMA TC 2 and UL 651. Use suitable type of conduit as indicated on the Contract Drawings. Conduit shall be listed and marked for use with 90° C insulated conductors.
- B. Fittings: NEMA TC 3, TC 9.
- C. Spacers: Tyrene, or equal. Spacers shall provide a minimum of 1 1/2" (38 mm) of separation between ducts and 3" (78 mm) beneath ducts.
- D. Conduit Cement: Weld-on No. P7 or equal.
- E. Joint Primer: Weld-on No. 717, or equal.
- F. Duct: ANSI/ASTM Standard F512 with minimum modulus 500,000 psi (3447 E+09 Pascal)

2.04 RTRC CONDUIT AND FITTINGS

- A. Reinforced Thermosetting Resin Conduit (RTRC), standard wall complying with NEMA TC 14 and UL 1684, Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
- B. RTRC conduit and fitting shall be manufactured by Champion Fiberglass, FRE Composites, United Fiberglass of America, or approved equal.

2.05 CONDUIT EXPANSION AND DEFLECTION FITTINGS

- A. UL-listed, consisting of two (2) threaded end couplings, bronze for dry locations. Either hot-dip galvanized malleable iron, hot-dip galvanized ductile iron, or hot-dip galvanized ASTM A48, Class 30A gray iron for wet locations.
- B. An ASTM D2000, Grade 2BC420 neoprene sleeve attached to the end couplings by ASTM A167, Type 304 stainless steel bands. The sleeve shall accommodate the following movements without collapsing or fracturing the conduits and damaging the wiring:
 - 1. Axial expansion or contraction from normal 3/4 inch (19 mm) minimum in either direction.
 - 2. Parallel misalignment of the axis of couple conduit runs, in any

direction, of $\frac{3}{4}$ inch (19 mm) minimum.

3. Angular misalignment of the axis of coupled conduit runs, in any direction, of 30 degrees minimum.
- C. Where applicable, a tinned flexible copper braid bonding jumper, integral with the expansion fitting, attached to the end couplings to provide electrical continuity.

2.06 BUSBARS

- A. All busbars shall be made of solid, high electrical conductivity copper or aluminum. Air-insulated busbars shall be furnished with silver-plated surfaces for positive contact and low resistance.
- B. The busbar's continuous, overload, and short-circuit ratings shall be compatible with the equipment ratings shown herein.

2.07 STEEL CABLE TRAYS

- A. Comply with NEMA VE 1. Steel trays shall be ladder type or solid-bottom type as required by governing code or indicated on the Contract Drawings, shall be hot-dip galvanized after fabrication in accordance with ASTM A123, and shall be supported in a manner suitable for the seismic rating of the installation.
- B. Ladder Type Cable Trays:
1. Dimensions: Inside clear width shall be as shown on the Contract Drawings. Inside usable depth shall be 4 inches (102 mm) minimum. Outside depth shall be 6 inches (152 mm) maximum.
 2. Fitting Radius: 24 inches (610 mm).
 3. Rung Spacing: Maximum 9 inches (230 mm) between centers.
 4. Working Load: 100 pounds per linear foot (148.816 kg/m) on a maximum span of 8 feet (2440 mm) with a safety factor of 1.5, when tested in accordance with NEMA VE 1.
 5. Fabrication: Straight sections and fittings shall consist of rungs located between channel-shaped side rails having outward projecting flanges. Rungs shall provide a flat, cable support surface at least 1-1/4 inch (32 mm) wide. Rungs shall be welded to the side rails.
- C. Solid Bottom Type Cable Trays:
1. Dimensions: Inside clear width shall be as shown on the Contract Drawings. Inside usable depth shall be 4 inches (102 mm) minimum.
 2. Fitting Radius: 24 inches (610 mm).
 3. Working Load: 50 pounds per linear foot (74.408 kg/m) on maximum span of 8 feet (2440 mm) with a safety factor of 1.5, when tested in

accordance with NEMA VE 1.

2.08 FIBERGLASS CABLE TRAYS

- A. Fiberglass trays shall be ladder type, manufactured from fiberglass-reinforced polyester resin, in accordance with NEMA FG 1, as follows:
1. Dimensions: Inside clear width shall be as required. Inside usable depth shall be 4 inches (102 mm) minimum. Outside depth shall be 6 inches (152 mm) maximum.
 2. Fitting Radius: 24 inches (610 mm).
 3. Rung Spacing: Maximum 9 inches (230 mm) between centers.
 4. Working Load: 50 pounds per linear foot (74.408 kg/m) on a maximum span of 8 feet (2440 mm) with a safety factor of 1.5.
 5. Fabrication: Straight sections and fittings shall consist of rungs located between channel- shaped side rails.
 6. Flame Spread Index: ASTM E84,25 maximum.
 7. Smoke Density: ASTM E84,450 maximum.

2.09 ALUMINUM CABLE TRAYS

- A. Aluminum cable trays shall be ladder type conforming to NEMA VE 1 fabricated from wrought aluminum alloy. Supports such as brackets and clamps, and bolts and nuts shall be hot-dip galvanized steel.
- B. Working loads and dimensions shall be as specified above for ladder type steel cable trays.

2.10 HIGH DENSITY POLYMER CONCRETE TRENCH

- A. The outdoor cable trench shall be a continuous trench as specified herein and shown on the Contract Drawings.
1. The cable trench shall be Plastibeton as manufactured by Synertech Inc., or approved equal. The cable trench shall be totally nonporous and shall resist the degrading action of freeze/thaw cycles. The material shall also be unaffected by grease, oil, and salt. It shall have lockable covers for additional security.
 2. The cover material shall be of a dielectric characteristic, non-metallic, and shall be reinforced with a glass fiber for impact resistance.
 3. The weight of each cover shall not exceed the allowable handling weight as per OSHA requirements.
 4. Cover shall sit inside trench to allow flush to grade installation.
 5. The cable trench system shall include the U-shaped channel, covers,

and all necessary special fittings.

6. The cable trench shall be of the self-supporting type equipped with easy access covers.
7. The cable trench including Polymer Concrete covers shall be rated to support a minimum load of 40,000 lbs without failure, H20 load rating.
8. The cable trench shall be provided with an integral divider(s), installed as per location detail.

2.11 METAL FRAMING AND WIREWAYS

- A. Metal Framing (Continuous Slot Metal Channel System): Shall be suitable for the intended application and shall comply with the following requirements:
 1. Channel: Steel, ASTM A569. Where used as a raceway and lighting fixture support, channel shall be listed by UL as complying with UL 5 for use as surface raceway and support for lighting fixtures with electric discharge lamps.
 2. Configuration: Single channel or two single channels welded together. Channels shall accept spring-held steel nuts.
 3. Channel, Pipe Clamps, and General Fitting Finish: Hot-dip galvanized after fabrication, ASTM A123 or A153, as applicable.
 4. Nuts, Bolts, and Screws Finish: Electro-deposited zinc coating, ASTM B633, Class Fe/Zn 5, Type III.
- B. Wireways: Galvanized sheet steel with screw covers, complying with UL 870.

2.12 HANGERS AND SUPPORTS

- A. Hanger Rods: ASTM A575 or ASTM A576. Threaded, hot-rolled steel, 3/8-inch (9.5 mm) diameter minimum with electro-deposited zinc coating, conforming to ASTM B633, Fe/Zn 5, Type 111.
- B. Trapeze, Multiple Conduit Hangers:
 1. Fabricated of two or more galvanized steel hanger rods, a steel channel horizontal member and U-bolts, clamps and other attachments necessary for securing hanger rods and conduits.
 2. Horizontal Member: Continuous slot galvanized metal channel single or double, as required.

2.13 ANCHORS

- A. Expansion Anchors: FS FF-S-325, Interim Amendment 3, Group VIII, Type 1. Metal shall be ASTM A108 steel with electro-deposited zinc coating according to ASTM B633.
- B. Equipment Anchorages: Steel leveling plates, angles, and studs shall comply with ASTM A36, and shall be hot-dip galvanized in accordance with ASTM A153.

2.14 OUTLETS, JUNCTION, AND PULL BOXES

- A. Comply with the requirements of NFPA 70.
- B. Surface Mounted Outlet and Switch Boxes: Cast iron alloy, hub-type with cover gasket in wet locations, complete with painted steel cover plates and complying ASTM A48. In dry areas use pressed steel.
- C. Pull and Junction Boxes:
 - 1. Dry Locations Galvanized, 16 MSG minimum, sheet steel with welded seams and screw covers.
 - 2. Wet Location: NEMA Type 4X, hot-dip galvanized cast iron complying with ASTM A48 and A153.

2.15 WIRING DEVICES

- A. Terminal Blocks: Comply with NEMA ICS 4 and UL 1059. Except where indicated otherwise, blocks shall be of the screw type with washer style head to accommodate terminals specified. Base and inter-terminal barriers shall accommodate terminals for No. 8 AWG (8 mm²) and smaller stranded copper wire connectors. The metallic parts shall be non-ferrous and corrosion-resistant. Circuits operating on different voltages or frequencies (AC, DC) shall be brought out to separate terminal blocks and identified with permanent labels. These terminal blocks shall be identified and provided with 20 percent spare terminals, over those required for circuit wiring.
- B. Receptacles: Comply with UL 498 and NEMA WD 1. Heavy-duty, general-purpose, rated 120 V, 20 A, single phase, duplex with ground fault circuit interrupter, with fire-resistant, non-absorptive, hot-molded phenolic composition bodies and bases, with metal ears suitable for mounting in specified metal outlet box.
- C. Switches: Comply with UL 20 and NEMA WD 1. Heavy-duty, AC general use, snap type, toggle- operated and rated 20 A, 120-240 V. Switches shall be single-pole, double-pole, one-way or three-way, as indicated on the Contract Drawings. Shall have hot-molded phenolic composition bodies and bases with metal ears for mounting in specified metal outlet box.
- D. Identification of Parts: Electrical components shall be permanently marked to the lowest level of repair and replacement with part number identification which coincides in all cases with the manufacturer's latest data. Nameplates shall be provided on major equipment items with adequate space for the addition of identification numbers as directed by Caltrain.
- E. Equipment Identification Nameplates: Nameplates shall be attached at the center or center middle of the equipment, in a neat manner, depending on the space available, or as specified, using screws.

2.16 WARNING SIGNS

- A. Warning signs are specified in Section 34 31 03, General Traction Power Requirements.

2.17 NAMEPLATES AND MARKINGS

- A. Nameplates and marking are specified in Section 34 31 03, General Traction Power Requirements.

2.18 SEALING COMPOUND

- A. A two-part silicone foam shall be used to prevent passage of fire, smoke, toxic gases, and water. Sealing compound shall be UL 1479 listed. Approved products include:
 - 1. Dow Corning 3-6548 Silicone RTV Foam, as manufactured by Dow Corning Corporation, Midland, Michigan 48640; or
 - 2. Chase-Foam, CTC PR-855, as manufactured by Chase Technology Corporation, 168 Railroad Street, Huntington Station, New York 11746.
- B. Sealing compound shall be installed in accordance with the manufacturer’s written instructions.

2.19 LIGHTING FIXTURES

- A. Outdoor Lighting fixtures are specified in Section 34 31 69.

2.20 GENERAL FABRICATION

- A. Equipment surfaces shall be smooth and free of defects which detract from safe performance and neat appearance. Such defects include, but are not limited to, gaps, burrs sharp edges, wrinkles, waves, and blemishes. Enclosing structures shall possess sufficient reinforcement to maintain structural integrity as well as the safety of their contents during transport, handling, installation and operations.
- B. Equipment Metal Enclosures: Enclosures shall be fabricated according to the requirements of the cited references listed in the Specifications.
- C. Threaded Fasteners:
 - 1. Fasteners shall be unified-type screw threads with dimensions in inches (millimeters) conforming to ANSI B1.1.
 - 2. All maintenance manuals shall be conspicuously marked on each page where metric threaded fasteners are used to assemble the component. Spare parts shall contain all necessary replacement isometric fasteners of the correct size and grade.
- D. Surface Treatment:
 - 1. Exposed non-wearing metal surfaces shall be painted. The surface shall first be thoroughly cleaned and treated with an anti-rust coating. The metal finish shall be a semi-gloss paint system that is the manufacturer’s standard for the service specified.
 - 2. Unfinished metal surfaces shall be coated with a layer of grease. The grease shall be removable by a petroleum-derived solvent.

- E. Finish Color: Enclosures shall have an exterior finish of ANSI light gray color. Interior colors of enclosures shall be the manufacturer's standard for the intended service.
- F. Touchup: Each set of traction electrification equipment shall be furnished with sufficient finish coat touchup paint to cover 5 percent of the metal surfaces.

2.21 SPECIAL TOOLS, TEMPLATES, AND TEST EQUIPMENT

- A. The Contractor shall furnish all special tools required for the operation and maintenance of all equipment furnished under this Contract. Special tools and equipment shall also include, but not be limited to, software and extension cards for relays, test blocks, racking handles, manual closing handles, adjustment tools and gauges and specialized test equipment for proper operation and maintenance of the substation. One set of tools and one set of test equipment to test all protective relays, circuit breakers and any other devices in the substation shall be provided. The Contractor shall submit a list of special tools, test equipment, gauges, and templates required herein for Caltrain to review for Contract compliance.
- B. The cost of special tools shall be included in the prices for equipment to be furnished.

PART 3 – EXECUTION

3.01 GENERAL

- A. Installation work shall be in accordance with applicable requirements of NFPA 70. Comply with the regulations of applicable state and local codes, public utilities commissions and the requirements of each serving utility, for their respective electrical service.
- B. Wire and cable, and the installation of both, shall comply with the requirements of AREMA C&S Manual, Section 10, Wire and Cable and CPUC GO95/GO128 and as follows:
 1. Terminate cable conductors, shield, and drain wire, if used, on the connector to prevent the inadvertent grounding of the shield or conductor connection via the connector shell to the equipment enclosure or to another unintended potential.
 2. Wire and cabling shall have EMI impulse protection for wiring and cables entering the equipment room or enclosure. EMI impulse protection shall consider and be consistent with the cable type, the cable source, and the potential EMI hazards to be protected against. Room entry and line entry impulse protection shall consist of line-to-line and/or line-to-ground protection, as appropriate, for each circuit type. Circuit protections on wires include combinations of lightning arrestors, transient suppressors, fuses, spark gaps, filters, ferrite beads and clamshells, etc.

3.02 PERFORMANCE

- A. Materials and equipment shall be applied, installed, and connected as

recommended by the manufacturer.

3.03 INSTALLATION

- A. External wiring between major electrical equipment shall be accomplished as shown on the Contract Drawings. Specific requirements for installation for basic materials in related Sections shall prevail over contrary requirement, if any, as specified in the following Articles of this Section 34 31 13.

3.04 CONDUIT, FITTINGS, AND ACCESSORIES

- A. Embedded and Buried Conduits:
1. Embedded and buried conduits shall be PVC unless otherwise indicated on the Contract Drawings. Underground conduits shall be direct buried or encased in a reinforced concrete envelope, as shown on the Contract Drawings. Conduits encased in concrete shall be properly supported and spaced with specified spacers, prior to concrete placement. Conduits shall be provided with 1/8-inch (3 mm) minimum polypropylene pull cords, secured at both ends.
 2. Electric power cable ducts shall be identified by warning tape laid in the excavation 8 inches (203 mm) above the ducts. Tape shall be heavy-gauge plastic, 6-inch (152 mm) minimum width, color yellow and be imprinted with a warning notice that an electric circuit is located below the tape.
 3. Stub-ups 30 degrees or greater for PVC conduit shall be galvanized rigid steel conduit unless otherwise indicated. Radius of bends shall be no less than 36 inches (914 mm). Conduit terminations shall be fitted with threaded insulating bushing, molded from high impact thermoset phenolic compound.
 4. Galvanized rigid steel conduit terminations shall be fitted with either grounding the threaded insulated bushings or plastic bushings with grounding locknuts.
 5. End of conduit stub-ups or stub-outs shall terminate 3 inches (76 mm) above finished floor or vertical surface, unless indicated otherwise.
 6. The ends of conduits, pull boxes, and junction boxes shall be properly capped or covered prior to concrete placement. Note that duct tape, spray foam sealer or other forms of non-permanent sealers are not acceptable.
 7. Conduits shall be pitched to provide moisture drainage to the nearest manhole, handhole, or pull box.
 8. Conduits shall be mandrelled first, then rodded, or wire brushed, and swabbed prior to cable installation, to remove foreign matter. After cleaning, conduit ends shall be recapped until cable pulling commences.
 9. Conduit stub-ups and ends of conduits exposed to moisture intrusion shall be sealed with conduit sealing compound following cable

installation. Spare conduits shall be capped. Unless otherwise required, underground stubs shall be extended a minimum of 5 feet (1.524 meters) from the traction electrification equipment foundation, capped and suitably identified on the surface.

10. Where conduits cross structural expansion joints, conduit expansion and deflection fittings, as specified, shall be installed at the expansion joints.
11. The ends of field cut conduits shall be reamed to remove rough edges. Cuts and field threads of galvanized rigid steel conduit shall be coated with cold galvanizing compound. The ends of PVC conduits and couplings that are to be joined shall be coated with conduit primer and cement for a length equal to the depth of the coupling or other fitting, to ensure a watertight connection, in accordance with the manufacturer's instructions.

B. Exposed Conduits:

1. Exposed conduits shall be galvanized rigid steel unless otherwise indicated on the Contract Drawings.
2. Conduit runs shall be made with approved couplings and unions. Right angle bends, offsets, and change-in-direction bends shall be made with standard elbows, conduit fittings, pull boxes, or formed with a hickey or power bender. Conduit runs shall be straight and true; elbows, offsets, and bends shall be uniform and symmetrical. Bends shall be made without kinking or deforming the cross-sectional contour of the conduit.
3. Conduits entering outlet boxes, pull boxes, panelboard enclosures, terminal cabinets, and similar equipment enclosures shall be attached to the box or enclosure with a locknut outside and a locknut inside tightened against the box or enclosure. Conduit shall be provided with end bushings. Where required by Code, conduit shall be provided with grounding bushings with copper jumper to the box or enclosure ground lug or bus. Conduits 1-1/4-inch (32 mm) trade size or larger shall be provided with insulating bushings. Conduits shall be securely fastened or supported within 12" of entry to enclosures (outlet boxes, pull boxes, etc.).
4. To ensure ground continuity, unleaded, conductive anti-seize compound shall be applied to conduit threads, couplings, and hubs before assembly.
5. Trapeze hangers or wall-mounted metal framing shall be used to support runs of conduits. Conduit clamps shall be used at the end of each run, at each elbow, and on each intermediate hanger to securely fasten each conduit in the group. The required strength of supports, and the size and type of anchors, shall be based on the combined weights of conduits, wire and supports, and stresses incurred during wire pulling.

3.05 CABLE TRAYS, METAL FRAMING, AND WIREWAYS

- A. Trays and wireways shall be supported by cantilever type metal frame support or hangers of sufficient strength to carry combined weights of tray and cable and the dynamic loads imposed during cable pulling.
- B. Electrical continuity shall be maintained between sections of steel tray by bolted copper braid and the steel tray connected to local grounding system by green colored insulated wire.

3.06 HIGH DENSITY POLYMER CONCRETE TRENCH

- A. The cable trench shall be installed by the Contractor within an excavated trench as specified, on locations shown on the Contract Drawings, and as specified herein.
- B. The trench shall allow for installation of crushed stone under and on the sides of the trench in accordance with the approved manufacturer's recommendations and as approved by Caltrain.
- C. The cable trench shall be installed with the top of the cable trench one (1) inch below the finished grade.
- D. Using a transit, prepare a line grade to set the channel at level in the excavation.
- E. Set the units into place in the excavation. The alignment of the sections shall be made with an instrument.
- F. Backfill material placed on each side of the channel shall be done simultaneously. The backfill shall be placed in four (4) inch lifts and compacted.
- G. Complete tamping the earth against the channel sidewalls and finish to final grade level with finish stone.
- H. Channel and covers shall be cut to size onsite with standard cutting equipment.
- I. All backfill material shall be specified in an Excavation Section.
- J. Keep trench free of construction debris, rocks or earth during construction. Remove foreign material from trench prior to placing cables and covers.

3.07 ANCHORS

- A. Install expansion anchors into hole of required depth and even diameter. Anchor shall be flush with concrete surface when expanded, with no evidence of movement.

3.08 OUTLET, JUNCTION, AND PULL BOXES

- A. Mount boxes on enclosure columns with machine screws.
- B. Install switch and outlet boxes on lock side of entry doors and 48 inches (1219 mm) above floor level.
- C. Install junction and pull boxes so that covers are accessible after completion of

the installation.

- D. There shall be no unused openings in boxes after completion of installation.

3.09 GROUNDING

- A. Installation of grounding for traction power equipment is specified in Section 34 31 16.

3.10 WIRING DEVICES

- A. Device Mounting: Convenience power receptacles and lighting switches shall be rigidly attached to outlet boxes by two machine screws.
- B. Wire Terminations: Power wiring shall be terminated with specified connectors. Provide adequate slack wire, one loop minimum, to prevent strain on terminations.

3.11 WARNING SIGNS

- A. Attach specified "Warning High-Voltage Keep Out" signs to exterior surfaces of traction power substation, switching station, and paralleling equipment enclosures and station supporting structures with tamper proof mechanical fasteners as specified in Section 34 31 03.

3.12 FIELD TOUCH-UP

- A. Galvanized Metal Surfaces: Coat damaged surfaces, to the strength and finish of the original coating, with polystyrene organic rich compound containing not less than 91 percent by weight metallic zinc powder in dried film.
- B. Painted Metal Surfaces: Clean, treat, and coat damaged surfaces with required rust inhibiting undercoating and finish coat paint system in accordance with manufacturer's instructions.
- C. Fiberglass: Reinforced Polyester Enclosures: Repair damaged surface with materials and methods recommended by manufacturer.

END OF SECTION

SECTION 34 31 16

TPF GROUNDING AND BONDING

PART 1 – GENERAL

1.01 REQUIREMENTS

- A. This Section specifies furnishing, installing, and testing of completed grounding and bonding systems to be used in Traction Power facilities (TPF) such as the Traction Power Substations, Switching Station, Paralleling Stations, and Wayside Power Cubicles.
- B. Grounding of Traction Power System shall follow industry guidelines, be configured so as not to compromise broken rail detection or adversely affect the railroad signal system, and meet the design criteria requirements of rail potential rise and personnel safety for step and touch potentials in AC system faults as defined in IEEE80.

1.02 REFERENCE STANDARDS

- A. American National Standards Institute (ANSI):
 - 1. C2 - National Electrical Safety Code (NESC)
 - 2. C37.20.6 - IEEE Standard for 4.76kV to 38kV Rated Grounding and Testing Devices Used in Enclosure
- B. American Society for Testing and Materials (ASTM):
 - 1. A666 - Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar
 - 2. B3 Soft or Annealed Copper Wire
 - 3. B8 Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
 - 4. B187 Copper bus Bar, Rod, and Shapes
 - 5. B231 Concentric-Lay-Stranded Aluminum 1350 Conductors
- C. European Standards (EN):
 - 1. 50122-1 Protective Provisioning Relating to Electrical Safety and Earthing
- D. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. 80 Guide for Safety in AC Substation Grounding
 - 2. 81 Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
 - 3. 142 IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems
 - 4. 367 IEEE Recommended Practice for Determining the Electric Power Station Ground Potential Rise and Induced Voltage from a Power Fault
 - 5. 837 IEEE Standard for Qualifying Permanent Connections

Used in Substation Grounding

6. 1100 IEEE Recommended Practice for Powering and Grounding Electronic Equipment
- E. National Electrical Manufacturers Association (NEMA):
 1. GR 1 Grounding Rod Electrodes and Grounding Rod Electrode Couplings
- F. National Fire Protection Association (NFPA):
 1. 70 National Electrical Code (NEC)
 2. 780 Standard for the Installation of Lightning Protection Systems
- G. Underwriters Laboratories, Inc. (UL):
 1. 467 Grounding and Bonding Equipment

1.03 RELATED SECTIONS

Related requirements are included in, but not limited to, the following Sections:

- A. 34 31 03 - General Traction Power Requirements
- B. 34 31 13 - Basic Traction Power Materials and Methods
- C. 34 31 69 – Traction Power Facility Exterior Lighting and Lighting Protection

1.04 SUBMITTALS

- A. Submit the following for PCJPB review:
 1. Shop Drawings:
 - a. Locations of ground rods, connectors, cables, etc., and details of connections, terminations and access points.
 - b. Manufacturer's catalog data for all proposed materials with installation recommendations.
 - c. Procedures and equipment for testing resistances and electrical continuity.
 2. Submit product data on the following:
 - a. Grounding conductors
 - b. Connectors, bushings and fittings
 - c. Exothermic welding process, components, materials, and molds
 - d. Ground rods, ground rod couplers and driving sleeves
 - e. Stone for surface application
 3. Submit TPF grounding system test plan and procedures for review and approval prior to testing. Test procedures submitted for approval shall include test report format and proposed probe placement and spacing intervals relative to the ground grid being tested.

4. The Contractor shall perform fall-of-potential tests in at least two (2) different directions (two traverses), resulting in at least two (2) test data plots.
5. Grounding system test reports shall include the following, as a minimum:
 - a. Sketch of grounding system being tested showing locations of test probes relative to the ground grid under test.
 - b. Make, model and calibration date of test instruments.
 - c. Weather conditions at time of test.
 - d. Plotted "S" curves resulting from the fall-of-potential tests. Shape of curves shall be satisfactory as determined by Caltrain demonstrating adequate probe spacing evidenced by a distinct horizontal section in the middle of the curve (refer to IEEE Std. 81). Unsatisfactory test data plots shall be rejected and retesting shall be required.
6. Provide as-built drawings for TPF ground grids and ground rod arrays.
7. Certification: Certified test reports verifying that ground resistance, when grounding and bonding is installed and connected to the ground grid, counterpoise, or ground rods, does not exceed the values specified in this specification.

PART 2 – PRODUCTS

2.01 MATERIALS

- A. General:
 1. Grounding and bonding equipment shall comply with the Contract Drawings, referenced standards and be UL listed for the required purpose.
 2. The grounding and bonding system shall have a design life of at least 40 years.
- B. Unless otherwise specified, the color of the insulation jacket of insulated ground conductors shall be green.
- C. Ground Rods:
 1. UL-listed copper-clad steel rods, $\frac{3}{4}$ inch diameter, nominal 10 foot sections complying with NEMA GR-1.
 2. Carbon steel core and tip, with plated copper cladding of at least 10 mils thickness.
 3. Use bronze ground rod couplers, threaded type, if required to provide the total rod lengths indicated on the Contract Drawings.
- D. Ground Grid and Counterpoise Wire and Cable:
 1. Bare copper conductor, Class B stranded, annealed, soft-drawn copper cable conforming to ASTM B3.

- a. Diameter: as shown on the Contract Drawings.
- 2. NEC Grounding and Equipment Grounding Conductors:
 - a. In accordance with NEC Table 250-94 or as otherwise indicated on the Contract Drawings.
- E. Fittings:
 - 1. All connections below ground (i.e. buried) shall be exothermic weld type connections.
 - 2. All above-ground connections shall be bolted type.
 - 3. All fittings shall be UL-listed.
- F. TPS, PS, SWS Enclosure Interior Ground Buses:
 - 1. Minimum ¼ by 2-inch copper bus bar mounted on stand-off insulators of sufficient length to permit bolted bus connections.
 - 2. Connect to substation ground grid at two locations using 1/c, bare copper cable (size as indicated on the Contract Drawings) and NEMA 2-hole lug cable connectors.
- G. Crushed stone for substation yard surface shall conform to the Earthwork Specification Section.
- H. Grounding of Surge Arresters: The grounding and bonding requirements shall be as indicated on the Contract Drawings.
- I. Personnel Ground Grids at Disconnect Switch Locations: Prefabricated wire mesh consisting of No. 6 AWG, bare copper wires in an 8 inch x 8 inch mesh with cross wires silver brazed at all intersections using silver brazing alloy and a non-corrosive flux. Backfill shall be clean crushed rock, ¾ inch maximum size, with a level surface flush with the adjacent finish grade. In areas unsuitable for the use of a below grade grounding grid, a metallic grating shall be provided as shown on the Contract Drawings.
- J. Bus Bars: ASTM B187, size 2 inches (50 mm) wide by ¼ inch (6 mm) thick, length, as required.
- K. Terminal Lugs:
 - 1. For 4/0 AWG (100 mm²) and Smaller Conductors: Copper compression terminal lugs.
 - 2. For 250 kcmil (125 mm²) and larger: Long barrel, copper, double-compression terminal lugs.
- L. Ground Connectors:
 - 1. O-Z Gedney, Type KG, or equal.
 - 2. Two-piece, designed for connecting grounding conductor to bus bar.
 - 3. Copper alloy body and silicon bronze bolt, nut and washer with interlocking clamp.
 - 4. Exothermic Welds: Size and type per manufacturer's recommendations.

- M. Jumpers: Copper braided or leaf-type flexible jumper, size as shown on the Contract Drawings.
- N. Bus Bar Insulators: Fibrous glass reinforced polyester insulator with ½ inch (13 mm) diameter threaded holes at both ends for bus bar installation, size as shown on Contract Drawings.
- O. Coal Tar Epoxy: Polyamide cured coal tar epoxy, DuPont Corlar 823 CTE, Koppers Company No. 3000M, PPG Industries 97-640 or 97-641, or approved equal, applied to a dry film thickness of 8 mils (0.203 mm) per coat.
- P. Epoxy Resin Encapsulation: Two-component epoxy resin type with plastic snap mold, as manufactured by Duriron Company, 3-M Company, or approved equal.
- Q. Elastomeric Pads: Elastomeric pads used for base plate insulation shall be 6 mm (¼-inch) thick and cut to the size of the base plate. Pads shall be one piece with pre-cut holes to allow installation over the anchor bolts.
- R. Fiber Sleeves and Washers: Sleeves and Washers used to isolate base plates from anchor bolts shall be manufactured from non-hygroscopic high strength fiber and in sizes to suit the base plate and anchor bolt arrangements. Sleeves and washers shall have a minimum thickness of 1/8 inch (3 mm).

PART 3 – EXECUTION

3.01 GENERAL

- A. Install complete traction power substation, switching station, paralleling station, and wayside power cubicle grounding system as shown on the Contract Drawings, including, but not limited to, ground grid, test well, and earth electrodes (ground rods). Materials shall be as specified in Section 34 31 13 and in this specification. System shall be independent of but bonded to the rail return bus and shall include connections to the lightning protection system. The Contractor shall provide a facility for connections to track impedance bonds. Installation shall conform to ANSI C2 (NEC) and NFPA 70 (NEC), and the requirements of the utility company, Pacific Gas and Electric Company.
- B. A uniform/standardized grounding and bonding scheme shall be designed and installed throughout the entire electrified system in accordance with the requirements as specified herein, IEEE, EN, NEC, NESC and CPUC General Orders, to ensure proper return circuits for the traction power supply and fault currents, and to provide safety for employees and the general public.
- C. All exposed non-current-carrying metallic parts, liable to become energized from the TES under short circuit or fault conditions, shall be directly connected to the traction return circuits.
- D. Conductor splice case grounding and bonding requirements shall comply with the manufacturer’s recommendations and NEC.
- E. Connections to ground rods and buried ground / bond connections shall be exothermically welded. Connections between grounding conductors and equipment enclosures shall utilize two- hole compression lugs.
- F. Each grounding conductor that passes through a foundation and/or wall shall be provided with a water-stop.
- G. All existing and/or new utility services shall be grounded and bonded in

accordance with the service requirements of the respective utility owners.

- H. The shields of all communication cables shall be grounded at one end only. Where a cable is routed between a prefabricated and/or wayside equipment enclosure and field devices (external to the equipment enclosure) the cable shield shall be grounded at the equipment enclosure end, as close as practicable to the point of entrance / emergency (as defined in the NEC) or shall be interrupted as close to the point of entrance / emergency as practicable by an insulating joint or equivalent device. The Contractor shall install fiber optic communication cables, as indicated on the Contract.
- I. Copper communication cables that are routed between a prefabricated and/or wayside equipment enclosure and field devices (external to the equipment enclosure) shall have surge protection.
- J. Grounding for equipment shall consider and employ the IEEE Std 1100, sections 3.3, 4.9, 8.5, 9.9, 10.2, and 10.4, when applicable.
- K. TPF enclosure doors shall be bonded with flexible metal bonding straps instead of reliance on hinges for electrical continuity.

3.02 TPF EARTH ELECTRODE SYSTEM INSTALLATION

- A. Place ground rods in compacted backfill around foundations. Rods in drainage gravel beds shall project through beds and into underlying undisturbed earth for not less than ten feet (3,050 mm). Drive rods either by sleeve hammers or power drives. Install driving nuts on end of rod. Attach ground rods to ground grid at nodal points. Ground rods shall be driven so the top of the rod is at the same depth as the associated grid cable.
- B. Use terminal lugs to connect grounding conductors to equipment enclosures. Secure connector or terminal lugs to the conductors in order to engage all strands equally by using tools and pressure recommended by the manufacturer.
- C. Exothermically weld connections to ground rods in manholes and handholes as shown on the Contract Drawings.
- D. Ground bus and conductors installed underground, unless otherwise protected, shall be laid slack. Install no conductors in gravel beds. Grid conductors shall be buried at least 18 inches (458 mm) (including the crushed stone surface layer).
- E. Attach lightning down conductors and equipment grounding cables to earth electrode system and enclose exposed sections in non-metallic conduit. Either exothermically weld or braze connections to the earth electrode system.
- F. Personnel ground grids 6 feet long by 4 feet wide shall be installed at all disconnect switch operator locations. The grid shall be installed on the operator's side of the switch, 6 inches below finished grade, and shall be connected to the switch support structure by a 4/0 AWG ground conductor exothermically welded to two different conductors of the ground grid and to the switch support structure (and to the counterpoise when applicable), as shown on the Contract Drawings. The grid shall then be backfilled with crushed rock, maximum size 3/4 inch. Grounding platforms 6 feet long and 4 feet wide shall be installed where the installation of a buried grounding grid is not feasible. Platforms shall be constructed of galvanized steel members sized to safely support personnel.
- G. Bond and ground all metallic TPF perimeter fences as indicated on the Contract Drawings.

- H. Maximum resistance of individual or isolated ground rods shall be 25 ohms. Maximum overall grounding system resistance to ground shall be as shown on the Contract Drawings.
- I. Trenching, excavating and backfilling for installation of underground grounding conductors: in accordance with the Contract Documents. Stone shall be kept clean and free of contaminants.
- J. Install ground grid conductors and associated ground rods, connections and fittings as shown on the Plans.
- K. Perform exothermic welds in strict accordance with manufacturer's instructions. Test all completed exothermic welds by striking with a 2-pound hammer. If cracks develop after striking, replace weld at no additional expense to Caltrain.
- L. Bond the rebar in all foundation footings and slabs to the substation ground grid using approved exothermic weld fittings intended for this application. Coat these welds with bitumastic before encasing them with concrete.
- M. Drive ground rods vertically into earth using approved driving sleeves until top of rod is at least one (1) foot below final grade. If obstructions are encountered during driving, re-drive rod at a 30-degree angle from vertical. If the full length of the rod still cannot be driven entirely into the earth, Contractor shall note the rod location(s) and continue installing the remaining rods shown on the Plans. Before backfilling over the grid, Contractor shall advise Caltrain of the locations at which rods could not be driven to the prescribed depth. Contractor shall then complete rod installation, per the direction of Caltrain.
- Q. The traction power substation, switching station and paralleling station ground grids shall be measured for resistance to remote earth prior to connection of rail return, transmission line, and wayside counterpoise systems. Two (2) independent measurements, using the fall of potential method, shall be made for each individual station grid. Test reports shall be provided as described in Section 1.4, Submittals.
- R. If station ground grid resistance measures above the design value indicated on the Contract Drawings, additional ground rods shall be added under the direction of Caltrain until grid resistance falls below the design value.

3.03 TPF EARTH ELECTRODE SYSTEM TESTING

- A. Before connecting each TPS facility enclosure ground bus to the facility ground grid or electrode system, test the resistance of the completely installed ground grids in accordance with IEEE Std. 81, using the fall-of-potential method. Tests shall be made in the presence of Caltrain.
- B. Testing shall be performed by a NICET or NETA-certified test technician with demonstrated experience in the resistance testing of power substation ground grids. Test frequencies shall be selected to minimize potential interference from 60 Hz induced voltages and harmonics thereof, and stray 60 Hz AC and BART/VTA DC currents.
- C. Test reports shall include graphically plotted results of the fall-of-potential tests taken from at least two transverses. Data points and resulting plots shall be made with care and are subject to PCJPB review.
- D. If tests indicate that the resistance of the ground grids exceeds the design value, Caltrain shall be immediately notified. Under Caltrain's direction, several

additional ground rods will be added to the substation ground grid to decrease grid resistance, and the substation grid resistance re- tested. This process shall be repeated if necessary until TPS ground grid resistance is less than or equal to the design value.

3.04 ELECTRICAL EQUIPMENT SUPPORTING STRUCTURES

- A. Make electrical supporting structures electrically continuous and bond them to the TPF ground grid if they are inside the TPF perimeter fence, as shown on the Contract Drawings.

3.05 TPF INTERIOR ELECTRICAL POWER AND LIGHTING SYSTEMS

- A. For switchgear, switchboards, etc. the following requirements shall apply:
 - 1. The equipment grounding conductors shall be connected to the ground bus in the enclosure with suitable pressure connectors.
 - 2. Metallic conduits, which terminate without mechanical connection to the housing, by grounding bushings and grounding conductor to the equipment ground bus.
 - 3. For service entrance equipment, the grounding electrode conductor shall be connected to the ground bus.
- B. Exterior transformers supplying interior service equipment shall have the neutral grounded at the transformer secondary and a grounding electrode shall be provided at the transformer.
- C. In the case of separately derived systems (i.e. transformers downstream from service equipment), ground the secondary neutral at the transformer to either nearest component of the grounding electrode system of the ground bus at the service equipment.
- D. Interior electrical equipment shall be provided with a ground lug for termination of the equipment grounding conductor.
- E. Ground lugs shall be provided in each box and enclosure for equipment grounding conductor termination.
- F. Panelboards shall contain a ground bus, bolted to the housing, with sufficient lugs to terminate the equipment grounding conductors.
- G. Bond the equipment grounding conductor to each pullbox, junction box, outlet box, device box, cabinets, and other enclosures through which the conductor passes.
- H. Ground light fixtures to the equipment grounding conductor of the wiring system.
- I. Feeder and branch ac power and lighting circuits shall have a separate insulated equipment grounding conductor.
- J. All connections to the substation ground system, except for lightning protection down conductors, shall be made via the enclosure ground bus; direct connections from equipment inside the enclosure to the ground grid will not be permitted.

3.06 GROUNDING OUTDOOR LIGHTING POLES

- A. The Contractor shall ground outdoor lighting poles via ground lugs and #4/0

AWG insulated copper ground cable to 3/4-inch diameter, 10-foot long (minimum) copper clad steel ground rod as shown on the Contract Drawings.

3.07 PULL BOXES AND MANHOLES

- A. Ground all exposed metal objects within pull boxes and manholes.
- B. All non-current carrying conductive parts of manholes, handholes, pull boxes, splices boxes, metallic raceway and/or cable tray systems, etc. shall be bonded and grounded. The ground conductor shall be at least #6 conductor and sized in accordance with the NEC.
- C. An insulated equipment grounding conductor shall be provided in each duct of a ductbank system containing high voltage conductors. The equipment grounding conductor shall be at least 2 AWG and sized per NEC. The equipment grounding conductor shall be bonded to the switchgear ground bus, to all manhole hardware and ground rods, to the cable shielding grounding provisions of high voltage cable splices and terminations, and equipment enclosures.
- D. Metallic conduits which terminate without mechanical connection to electrical equipment housing by means of locknut and bushings or adapters, shall be provided with grounding bushings. Grounding bushings shall be connected to the equipment ground bus or enclosures as applicable.
- E. All metallic conduit systems shall contain an equipment grounding conductor.
- F. Apart from non-metallic feeder conduits that carry a ground conductor from exterior transformer to interior or building mounted service entrance equipment all non-metallic conduit systems shall contain an equipment grounding conductor.
- G. Conduit containing only a grounding conductor which is provided for mechanical protection of the conductor shall be bonded to the conductor at the entrance and exit from the conduit.

3.08 WAYSIDE POWER CUBICLES (WPC)

- A. WPCs shall be grounded by separately driven ground rods at opposite corners and connected to structural steel grounding pads. Motorized disconnect switches shall be provided with ground mats and bonding in compliance with IEEE Std. 80 Guide for Safety in AC Substation Grounding, as indicated on the Contract Drawings.
- B. Provide at least one (1) ground test station at each wayside power cubicle enclosure.

3.09 SCADA, COMMUNICATIONS, AND/OR ELECTRONICS SYSTEMS

- A. SCADA, communications, and/or electronic systems shall be grounded and bonded in accordance with the requirements as specified in NFPA 70E, NFPA 75, ANSI/TIA/EIA-607, NEC and ITU standards.
- B. Provide two separate grounds for all SCADA, and/or electronic systems – one for the equipment chassis and one for signal reference ground. Provide one chassis ground for communications. The signal ground shall be electrically isolated from building steel and non-current-carrying conductive entities.
- C. Solid copper ground bars designed for mounting on the framework of open or cabinet-enclosed equipment racks with minimum dimensions of 3/8" (thickness) by 3/4" (width) shall be provided. Ground bars within equipment racks shall be

bonded together using solid copper splice plates.

- D. A screw lug-type terminal block or drilled copper strip, for termination of the equipment grounding conductor, shall be provided at the top of backboards used for communications cross-connect systems

END OF SECTION

SECTION 34 31 19

LOW VOLTAGE WIRE AND CABLE

PART 1 – GENERAL

1.01 SCOPE

- A. This Section specifies the furnishing and installation of low voltage 600 V class insulated cables and associated splices, terminations, and other accessories and materials as shown on the Contract Drawings and as required for a complete installation.

1.02 RELATED SECTIONS

Related requirements are included in, but not limited to, the following Sections:

- A. 34 31 03 - General Traction Power Requirements
- B. 34 31 13 - Basic Traction Power Materials and Methods
- C. 34 31 89 - TPF Enclosures
- D. 34 31 23 - Underground Duct Banks
- E. 34 31 76 - TPF Testing and Commissioning

1.03 REFERENCES

All cable furnished under this Section shall be in accordance with the latest applicable standards of the IEEE, ANSI, NFPA, NEMA, ICEA, and UL with regard to material, design, construction, and testing. The standards applicable shall include, but not be limited to, the following:

- A. American Society for Testing and Materials (ASTM):
 - 1. B1 Hard Drawn Copper Wire
 - 2. B2 Medium-Hard Drawn Copper Wire
 - 3. B3 Standard Specification for Soft or Annealed Copper Wire
 - 4. B8 Standard Specification for Concentric-Lay Stranded Copper Conductor Hard, Medium- Hard, or Soft
 - 5. B33 Standard Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes
 - 6. B496 Standard Specifications for Compact Round Concentric-Lay Copper Conductor
 - 7. D2802 Ozone-Resistant Ethylene Propylene Rubber Insulation for Wire and Cable

8. D3005 Low Temperature Resistant Vinyl Chloride Plastic Pressure Sensitive Electrical Insulating Tape
- B. Insulated Cable Engineers Association (ICEA):
1. S-95-658 Standard for Nonshielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy
 2. S-105-692 600 V Single Layer Thermoset Insulated Utility Underground Distribution Cables
- C. Institute of Electrical and Electronics Engineers (IEEE):
1. 525 Guide for the Design and Installation of Cable Systems in Substations
 2. 1202 Flame Testing of Cables for Use in Cable Tray in Industrial and Commercial Occupancies
- D. National Electrical Manufacturers Association (NEMA):
1. WC-26 Bi-national Wire and Cable Packaging Standard
 2. WC70 Standard for Nonshielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy
- E. National Fire Protection Association (NFPA):
1. 70 National Electrical Code (NEC)
- F. Underwriters Laboratories (UL):
1. 44 Thermoset-Insulated Wires and Cables
 2. 62 Flexible Cord and Fixture Wire
 3. 83 Thermoplastic Insulated Wires and Cables
 4. 510 Insulating Tape
 5. 854 Service Entrance Cables
 6. 1581 Reference Standards for Electrical Wires, Cables and Flexible Cords
- G. Federal Specifications (FS):
1. HH-I-553 Insulation Tape, Electrical (Rubber, Natural and Synthetic).

1.04 SUBMITTALS

Submit the following in accordance with Section 34 31 03:

- A. Descriptive literature, catalog data, and other pertinent information for cable, splices and accessories sufficient to clearly demonstrate compliance with the Contract Documents.
- B. Proposed cable lubricants and associated lubricating devices.
- C. Proposed cable pulling equipment including cable grips, pulling rope, tensiometers, swivels, and cable pullers (winches).
- D. As-built lengths of all cable installed under this Contract.
- E. Product Data: Shall consist of manufacturer's standard catalog cuts, descriptive literature and diagrams, in 8½ X 11-inch format, and in sufficient detail so as to clearly indicate compliance with all specified requirements and standards.
- F. Product Certification: Signed by manufacturer certifying that products comply with the specified specification requirements.
- G. Report of Field Tests: Certified copies of field tests.
- H. Submit certified shop test reports for wires and cables.
- I. Submit field test results for wires and cables, including megger readings with the method used.

1.05 QUALITY ASSURANCE

- A. Cable Manufacturers' Qualification: Not less than fifteen (15) years experience in the actual production of the specified products.
- B. Workmanship shall conform to the best modern practices in the manufacturing of a rugged, durable, and safe product for use in a public transportation system. Materials used shall be new and of the highest commercial grade as specified.
- C. The Insulated Cable shall be manufactured and tested under the control of a Quality Assurance system that conforms to the requirements of ISO 9000.
- D. The Quality Assurance system shall demonstrate conformance to the above criteria by having passed yearly quality audits conducted by outside independent organizations.

1.06 WARRANTY

- A. The Contractor shall agree to replace any length of cable installed by the Contractor which fails during normal use within one (1) year of issuance of the Certificate of Compliance, provided immediate written notice of such failure is given to the Contractor with all reasonable opportunity provided thereto to inspect such failure.

PART 2 – PRODUCTS

2.01 GENERAL

- A. Water-based, gel-type, high-performance cable-pulling lubricants shall be utilized in accordance with cable manufacturer recommendations. Minimum cable pulling lubricant requirements shall include a UL Listing and a non-combustible residue.
- B. The cable shall be suitable for use in wet and dry locations in underground duct systems, direct burial and cable tray applications. The cable shall be rated 90° C for normal operation, 130° C for emergency overload condition and 250° C for short circuit conditions. Emergency overload operation may occur for periods up to 100 hours per year and with as many as five (5) such 100- hour periods within the lifetime of the cable.

2.02 600 V CLASS CABLE

- A. The low voltage cable shall be UL-type RHH/RHW-2 or XHHW; copper conductor, suitable for raceway or cable tray use unless otherwise indicated. All wires, cables, splices, and terminations, for which there are established UL standards, shall bear the UL label.
- B. Conductor:
 - 1. ASTM B8 Class B stranded, AWG/kcmil and number, as required, or as shown on the Contract Drawings.
- C. Insulation:
 - 1. 600 V class EPR or XLPE insulation meeting or exceeding the requirements of NEMA WC 70 and UL 44.
- D. Jacket:
 - 1. Polyvinyl chloride jackets conforming to ICEA S-95-658/ NEMA WC70, UL 44, and vertical tray flame test of UL 1581.

2.03 CABLE IDENTIFICATION AND LABELING

- A. The following information shall be printed on jacket, using contrasting indelible color ink, at intervals per NEMA WC70, WC71 and WC74 as applicable:
 - 1. The words: "Property of CALTRAIN"
 - 2. Manufacturer's name and plant, and year of manufacture
 - 3. Conductor size and material
 - 4. Voltage rating
 - 5. Insulation type and thickness (mils)
 - 6. Jacket type and thickness (mils)

7. UL designations
 8. Other appropriate conductor information
- B. Color-Coding for Power Conductors:
1. Insulation or covering of wires and cables shall be factory color-coded by the use of colored compounds or coatings. The color-code shall be followed consistently throughout the performance of the work.
 2. Upon written request of Contractor, Caltrain may permit the use of other methods of color coding, including the following methods in lieu of the wire or cable manufacturer's color coding, when limited quantities of wire and cable are involved, for sizes No. 8 AWG and larger. Method used shall conform to NEC, and be approved by Caltrain.
 - a. For dry locations only, spiral application of 3/4-inch wide, colored pressure sensitive plastic tape, half lapped for a distance of not less than six (6) inches may be used. To prevent unwinding, the last two wraps of tape shall be applied with no tension.
 - b. For wet or dry locations, application of three, 3/16-inch wide, colored, fungus- inert, self-extinguishing, self-locking, nylon cable ties spaced three (3) inches apart may be used. The ties shall be snugly applied with a special tool or pliers, and any excess removed.
 - c. Each wire and cable shall be color-coded at all terminal points, manholes, boxes, or other similar enclosures.
 - d. Color markings shall be applied so as not to damage the manufacturer's identification markings beyond legibility.
- C. Cable Tags:
1. Stainless steel metal tags No. 28 gauge and 3/4-inch wide, embossed with letters and numbers 5/16-inch high, with No. 14 AWG copper or nylon, weather-resistant cable ties, or stainless steel cable ties.
 2. Single conductor signal and control wiring may be identified with "Quiklabels" manufactured by W.H. Brady Company, or approved equal.
 3. In accordance with Section 34 31 13, Basic Traction Power Materials and Methods.

2.04 SPLICING AND TERMINATING MATERIALS

- A. Splicing and terminating shall be as specified in this Section. Details of special splicing and terminating shall be as shown on the Contract Drawings or in accordance with manufacturer's recommendations. Any splicing or terminating

methods other than those specified below, for which the components are in accordance with the requirements of this Section, shall be submitted for approval.

- B. Cable splices shall have documented equal-or-better electrical and mechanical characteristics than the cable being spliced. All splicing, terminating, and arc-proofing materials shall be compatible so that no one material will adversely affect the physical or electrical properties of any other or of the wire or cable itself.
- C. Splice materials shall be furnished in kit form with detailed instructions included. All materials for making splices and terminations shall be specifically designed for use with the type of wire or cable, insulation, and the operating conditions of the specific application.
- D. Splices shall be made only in manholes or in handholes and with the approval of Caltrain.
- E. Cable termination fittings and lugs shall be compatible with the feeder cable and the switchgear, disconnect switch, or impedance bond to which the terminations are being made (refer to Section 34 31 13, Basic Traction Power Materials and Methods).
- F. Connectors: Subject to compliance with requirements of this Section, provide connectors of the following types:
 - 1. Solderless, uninsulated, high-conductivity, corrosion-resistant, compression connectors conforming to UL 467 and IEEE 837.
 - 2. Insulated, indenter-type compression butt connectors.
 - 3. Insulated, integral self-locking flexible shell, expandable spring connectors.
 - 4. Uninsulated, indenter-type compression pigtail connectors.
 - 5. Welded-type connectors.
- G. Terminals: Subject to compliance with requirements of this Section, provide terminals of the following types:
 - 1. Solderless, uninsulated, high-conductivity, corrosion-resistant, compression terminals conforming to UL 467 and IEEE 837.
 - 2. Insulated, compression terminals.
 - 3. Solderless, high-conductivity, corrosion-resistant, hex screw-type, bolted terminals.
 - 4. Welded-type terminals.
- H. Shrinkable Tubing: Subject to compliance with requirements of this Section, provide shrinkable tubing of the following types:

1. Either irradiated modified polyvinyl chloride or irradiated modified polyolefin heat shrinkable tubing;
2. Cold shrinkable tubing.

I. Tapes and Sealers:

1. Vinyl Tapes: Flame retardant, cold and weather-resistant, 3/4-inch or 1-1/2-inches wide, as required, and conforming to UL 510 and ASTM D 3005.
 - a. For interior, dry locations, provide seven mils, conforming to ASTM D 3005 (Type 1); Scotch (3M) No. 33, or approved equal.
 - b. For exterior or damp and wet locations, provide 8.5 mils, conforming to ASTM D 3005 (Type II); Scotch (3M) No. 88, or approved equal.
2. Rubber Tapes: Ethylene propylene rubber based, 30 mil splicing tape, rated for 130°C operation; 3/4-inch and wider (1, 1-1/2, 2-inches) as shown on the Plans or approved by Caltrain, conforming to ASTM D 1373 and FS HH-I-553 (Grade A); Scotch (3M) No. 130C, or approved equal.
3. Insulating Putty: Rubber-based, 125 mil, 130° C rated, anti-tracking, self-fusing tape; one-inch wide; Scotch (3M) No. 70, or approved equal.
4. Silicone Rubber Tapes: Inorganic silicone rubber, 12 mil, 130°C rated, anti-tracking, self-fusing tape; one-inch wide; Scotch (3M) No. 70, or approved equal.
5. Sealer: Liquid-applied, fast-drying sealant; Scotch (3M) Scotchkote, or approved equal.

J. Resin Filled Splices:

1. Epoxy Molded Type: Two-piece, snap-together molded bodies, sized for wire or cable, with two-part low velocity polyurethane insulating and sealing compound, rated for 600 V, using crimp-type wire connector; Scotch (3M) No. 87-A1, 87-A2 or 87-A3 compound, or approved equal.
2. Re-Enterable Type: Transparent, molded bodies clamped with stainless steel strain relief bar and shield continuity connectors, sized for wire or cable, with loosely woven polyester spacer web and jelly-like urethane formulation for permanent re-entry capability; Scotch (3M) No. 78-R1 through 78-R5, with No. 2114 compound, or approved equal.

K. Control Wires and Cables:

1. Splice shall be enclosed in a re-enterable splicing case. Where shielded cable is shown on the Plans, the shielding shall be continued through

the space. Shields shall be grounded at one location only unless otherwise shown on the Plans.

2. Terminations shall be insulated, indenter-type ring tongue terminals.

L. Switchboard Wires:

1. No splices are permitted.
2. Terminations shall be insulated, indenter-type ring tongue terminals.

2.05 MULTI-CONDUCTOR CABLES FOR SUBSTATIONS

A. Multi-conductor cable for low voltage power and control shall be utilized for SCADA, control, current transformers, low voltage power distribution and related functions at substations, switching station, and paralleling station sites.

B. Cable shall be suitable for use indoors or outdoors, in cable trays, conduit, underground duct, or direct buried in wet or dry locations.

C. Cable shall be rated 600 VAC minimum and for 90 degrees C rise.

D. Construction details include:

1. Conductors: Soft annealed copper per ASTM B-33, Class B stranding per ASTM B-8, compressed stranded.
2. Insulation: Flame retardant, cross-linked polyethylene (FR-XLPE). Color coding per ICEA S-73-532.
3. Shield: Overall shield consisting of helically applied 5 mil annealed copper tape with a minimum overlap of 10%.
4. Jacket: Heat, moisture, and sunlight resistant PVC.
5. Rip Cord: Provide a ripcord longitudinally under the jacket to facilitate stripping.
6. Grounding Conductor: Soft annealed copper per ASTM B-33, Class B stranding per ASTM B-8 sized in accordance with UL Standard 1277.
7. Assembly: Cabled with non-hygroscopic polyethylene fillers in order to give the cable a circular cross-section, when needed. Wrapped with a mylar binder.
8. Standards:
 - a. ANSI/ICEA S-73-532
 - b. NEMA WC 7
 - c. UL 44

- d. UL 1581
- e. UL 1685

PART 3 – EXECUTION

3.01 CABLE SHIPPING, STORAGE, AND HANDLING

- A. Cable shall be packaged in accordance with NEMA WC 26 and the requirements stated herein. Protective reel coverings shall be Level 3 or greater, in accordance with NEMA WC 26.
- B. Insulated Cable for this design package shall be furnished in accordance with the Plans and with the following requirements:
 - 1. A watertight seal shall be applied to each end of the cable to prevent moisture ingress during shipment or outdoor storage. The Contractor shall provide factory-applied caps to wire and cable sizes No. 4/0 AWG and larger unless otherwise shown on the Plans. End seals shall be heat-shrink, irradiated, modified polyolefin, and shall be sized for individual wires and cables.
 - 2. A durable, weatherproof label shall be securely attached to the outside of both flanges of each reel. Each label shall indicate the following:
 - a. Purchase order number
 - b. Name and address of manufacturer
 - c. Reel number
 - d. Total length of cable on reel
 - e. Description of cable
 - f. Tare and total weight of reel and rolling direction

3.02 PREPARATION

- A. Prior to pulling or laying wires and cables, clean raceway systems of all foreign matter and perform all operations necessary so as not to cause damage to wires and cables while pulling or laying.
- B. Prior to pulling wires and cables into underground conduit systems, place a feeding tube approved by Caltrain at the entrance of such systems.

3.03 INSTALLATION REQUIREMENTS

- A. Double-braided cable pulling rope shall be used for all cable pulls; the use of steel cable for cable pulling is not permitted.
- B. Cable ends shall be properly sealed before being pulled into ducts. Cable ends shall not be left with insulation exposed after cutting unless splicing is to be

performed immediately.

- C. Strip all nails from outside edges of reel heads before pulling of cable. Conveniently locate reels for feeding cable into the duct without excessive bending or possible injury to cable by abrasion. Reels shall be jacked to clear ground level or obstructions by at least six (6) inches before pulling of cable.
- D. Pre-lubricate ducts utilizing pumps, "front-end packs", and duct swabs where required to fully lubricate the entire length of duct in front of the advance of the cable. Continuously apply pulling lubricant to the cable itself at the duct entrance during the pull.
- E. Attach pulling ropes to cables with approved grips and swivels to prevent twisting of cable during pulling. The use of break-away swivels is not permitted.
- F. Pull cable into ducts and conduits under moderate tension. Manufacturers' recommended maximum pulling tension and minimum bending radius shall not be exceeded. Pulling tension shall be continuously monitored by an approved measuring device (tensiometer) equipped with a chart or digital recorder. Copies of the pulling tension chart recordings shall be provided to Caltrain for each cable pull.
- G. Station sufficient personnel between the reel and the duct entrance during pulling operations to inspect, control and direct the passage of the cable. Utilize split nylon tube-type duct shields and cable-feeding tubes to prevent chafing of the duct entrance and the cable.
- H. Do not permit cable to chafe on the ground, ballast, manhole edges, or any sharp surfaces. Provide timbers and flexible cable-pulling tubes to guide and protect the cable where necessary.
- I. Cables shall be arranged and neatly racked along the manhole walls. Provide sufficient bends and freedom of horizontal motion to accommodate normal cable thermal expansion and contraction. "Straight through" cable installations, without the additional bends and racking noted above will not be permitted.
- J. All Traction Power insulated cables shall be identified (tagged) in each manhole, handhole, and at each termination.
- K. Interconnection routing. Minimize emission and maximize immunity of power and signal conductors, by performing the following:
 - 1. Arrange wires, cables, and conduits to physically separate signals with different signal type, voltage and energy levels.
 - 2. Separate and shield circuits carrying power, high level signals, and low level signals.
 - 3. Use balanced circuits with coordinated current return paths.
 - 4. Minimize the loop area between sources and return conductors.

5. Use photo couplers to galvanically isolate circuit potentials when needed.
 6. Shield all sensitive signal conductors in suitable electric and magnetic shielding structures using appropriate combinations of steel conduit and shielded cable.
 7. Connect shields to appropriate system ground at the high energy end.
- L. Wire and Cable Installation:
1. General:
 - a. Keep wires and cable dry at all times.
 - b. Seal wire and cable ends with watertight end seals if splicing or termination does not follow at once.
 - c. Before splicing or terminating wires and cables, make a thorough inspection to determine that water has not entered the wires and cables or that the wires and cables have not been damaged.
 - d. Use adequate lubrication when installing cables in conduits or raceways. Any pulling compounds shall be compatible with the finish of the wires and cables furnished.
 - e. Wire or cable shall be installed directly from reel or coil and shall not be allowed to drag along the ground.
 2. Control Wires and Cables: Control wires and cables shall not be smaller than No. 14 AWG unless otherwise indicated on the Contract Drawings.
- M. Identification of Wires and Cables:
1. Each wire and cable shall be identified by its circuit in all cabinets, boxes, manholes, wireways and other enclosures and access locations, and at all terminal points.
 2. The circuit designations shall be as shown on the Contract Drawings. Tags shall be attached to wires and cables in such a manner as to be readily visible.
 3. The tag ties shall be wrapped around all conductors comprising the circuit or feeder to be identified.
 4. Wires and cables that are arc-proofed shall also be identified outside the applied arc proofing.

3.04 INSPECTION AND TESTING

- A. Inspection: Caltrain reserves the right to witness the manufacture, testing, and packaging of all conductors. The Contractor shall notify Caltrain not less than ten (10) days in advance of manufacturing and testing operations.

- B. Testing: The standard dielectric-withstand tests shall be performed on each reel of cable prior to shipment. A certified copy of the test report for each reel of cable shall be furnished to Caltrain prior to shipment. A copy of the test report shall also be packed with each reel. Test requirements shall be in accordance with NEMA WC 70.

3.05 FACTORY TESTS

- A. For quantities as shown on the Plans, regular dielectric-withstand and insulation resistance in water tests for wires and cables shall be performed in accordance with UL 44.
- B. Flame tests for wires and cables shall be performed in accordance with vertical tray flame test of UL 1581 F. Cable sizes larger than 1/0 AWG shall meet the vertical tray flame test requirements of IEEE 1202.
- C. The test results shall be certified for each reel/coil/box of wire or cable.
- D. Factory inspection and witnessing of tests by Caltrain may be required for all wires and cables furnished under this Contract. Caltrain reserves the right to require additional testing, or to waive factory inspection or witnessing of tests. The Contractor shall notify Caltrain fourteen (14) days in advance of the scheduling of such factory tests.

3.06 FIELD TESTS

- A. Inspect wires and cables at terminations and pull boxes for physical damage and proper connection.
- B. Verify continuity of each branch circuit conductor.
- C. The Contractor shall test all 600 V wires and cables installed under this Contract with a 1,000 V megohmmeter. Furnish Caltrain with a copy of the megger readings together with an outline of the method used. If, in the opinion of Caltrain, any reading is lower than that required by applicable codes, promptly replace the materials involved, at Contractor's expense, and retest.
- D. Cables shall be subjected to Acceptance Tests as specified below to ascertain that the dielectric strength of the cable insulation has not been impaired during installation, that the splices and terminations are properly made and to confirm the integrity of the cable system prior to energization. These shall include continuity tests and insulation resistance tests performed after the cable installation.
- E. Acceptance Tests: After installation of the entire length of cable, the Contractor shall perform the tests listed below on each cable in accordance with current NETA Acceptance Testing Specifications. To preclude damage to equipment and devices, the tests shall be conducted before the cable is terminated at electrical equipment. If terminations have already been made, cables shall be disconnected from the equipment for testing and shall be reconnected after completion of tests.

1. Dielectric Test
 2. Continuity Test
 3. Insulation Resistance Test
- F. Defective Cables:
1. Any cable installed under this Contract found defective during the testing shall be replaced with new cable at the expense of the Contractor.

END OF SECTION

SECTION 34 31 23

UNDERGROUND DUCTBANKS

PART 1 – GENERAL

1.01 SCOPE

- A. This Section specifies the furnishing, installation, connection, and site-specific detailed design of TPS concrete-encased duct banks, direct buried conduits, and pre-cast concrete manholes and handholes, as indicated on the Contract Drawings.
- B. The Contractor is responsible for preparing detailed installation drawings (plan, profile, and details) for the duct bank, manhole, and handhole work shown on the Contract Drawings. The Contract Drawings show a general layout of the facilities required at and adjacent to the TPS sites. The Contractor shall perform additional underground exploratory investigations as indicated on the Contract Drawings (i.e., test pits, utility detection services, etc.) to determine a clear path/space for all new underground duct banks, manholes and handholes. Revisions are to be made to the relevant Contract Drawings by the Contractor based on the underground exploratory investigations. These alterations are to be submitted to Caltrain, along with the accompanying duct bank profile and detail drawings, for approval prior to proceeding with the work in the field.

1.02 REFERENCE STANDARDS

- A. All work furnished under this Section shall be in accordance with the latest applicable standards of AASHTO, ASTM, NEMA, and National Electrical Code with regard to material, design, construction and testing, except for any specific variations provided in this Section. The standards applicable shall include, but not be limited to, the following:
 - 1. American Association of State Highway and Transportation Officials (AASHTO):
 - a. M199 Reinforced Concrete Manhole Sections
 - b. HS20-44 Live Loads for Highway Bridges
 - 2. American Society for Testing and Materials (ASTM):
 - a. A48 Gray Iron Casting
 - b. A438 Transverse Bending Test
 - c. C136 Coarse Aggregates
 - d. C150 Portland Cement
 - e. C827 Early Volume Change of Cementitious Mixtures

1.03 RELATED SECTIONS

Related requirements are included in, but not limited to, the following Sections:

- A. 34 31 03 - General Traction Power Requirements
- B. 34 31 13 - Basic Traction Power Materials and Methods
- C. 34 31 16 - TF Grounding and Bonding
- D. 34 31 89 - TPF Enclosures
- E. 03 20 00 - Concrete Reinforcing
- F. 03 30 00 - Cast-in-Place Concrete

1.04 SUBMITTALS

- A. Submit the following in accordance with Section 34 31 03:
 - 1. Catalog data on metallic and non-metallic conduit, all conduit couplings and fittings, manhole and handhole inserts, cable support material, waterproofing sealer, concrete curing compound, and concrete dye additive.
 - 2. Shop drawings of pre-cast manholes and handholes which show all accessories including layout of cable supports.
 - 3. Conduit Stub-Up Plans: Include for all locations where conduit transitions from below- grade to above-grade, such as at substation floor penetrations, switchgear, gantries, and negative returns at impedance bonds.
 - 4. Detailed plan and profile installation drawings for duct bank, conduit, manhole and handhole installation.

PART 2 – PRODUCTS

2.01 PRE-CAST MANHOLES AND HANDHOLES

- A. Manholes/handholes may be constructed monolithically or in sections. If the manhole is constructed in sections, the joint between sections shall be made watertight with an approved gasket or with an approved epoxy mortar grout.
- B. Manhole and handhole access openings shall be centered in the roof slab and duct bank knockouts shall be centered in the walls, unless otherwise noted. This shall be constructed in size and shape to accommodate the cast iron cover and frame as shown on the Contract Drawings.
- C. Manholes and handholes shall include duct bank knockouts, riser conduit knockouts, a sump with galvanized grate and a minimum depth of two (2) inches, a ground rod, 7/8-inch minimum diameter galvanized steel pulling irons (8 per manhole, 4 per handhole), cable racks, and cast iron cover with lifting hooks and/or finger holes.

- D. Size: Minimum inside dimensions of manholes/handholes shall be as indicated on the Contract Drawings.
- E. Design Loads: Manhole and handhole design loads shall consist of live loads, live load impact, dead load, soil loads, hydrostatic loads and any other expected loads that may occur.
 - 1. Live loads shall be for HS-20 for manholes and handholes that will be installed within the substation perimeter fence or along access roads.
 - 2. Live loads shall be for HS-20 for manholes and handholes that will be installed a distance of nine (9) feet or greater from the centerline of track or E-50 for manholes and handholes situated less than nine (9) feet from centerline of track.
 - 3. Avoid the theoretical underground track disturbance line.
 - 4. Impact loading shall be 30 percent of the live loads.
 - 5. Soil loads shall consist of an earth cover over manhole from zero (0) feet minimum to five (5) feet maximum. Average unit weight of earth shall be assumed to be 100 lbs. per cubic feet.
 - 6. Hydrostatic loading shall be a hydrostatic head of nine (9) feet above base of manhole.
- F. The final production shop drawings shall be approved and signed by a Civil or Structural engineer, registered in the State of California.
- G. Concrete: Cement for concrete shall be Portland cement, meeting the requirements of ASTM C150, Type I or Type II. Concrete shall be thoroughly cured and shall attain a compressive strength of at least 3,000 psi before delivery, and 4,000 before installation. The proportions of materials for concrete shall be as follows:
 - 1. Minimum number of sacks of cement per cu. yard of concrete = 7.
 - 2. Maximum size of coarse aggregate = $\frac{3}{4}$ inches.
 - 3. Maximum slump = 4 inches.
- H. Concrete reinforcing bars (if required) shall be in accordance with the provisions of the Contract Documents.
- I. Exterior surfaces of manholes/handholes shall be waterproofed with two coats of waterproofing sealer. The sealer shall be applied when the manholes/handholes are manufactured and touched up in the field as required to repair damage during shipping and to seal field penetrations. The sealer shall be applied in accordance with the manufacturer's recommendations.
- J. Grounding shall be in accordance with Section 34 31 16, TPF Grounding and Bonding.

2.02 MANHOLE AND HANDHOLE FRAMES AND COVERS

- A. Handhole frames and covers shall be as indicated on the Contract Drawings. Manhole frames and covers shall be cast from gray iron in accordance with the applicable requirements of ASTM A48, Class 30. The transverse bending test shall be considered the primary test for qualification and shall be conducted in accordance with the requirements of ASTM A-438. Covers shall be labeled with cast, raised identifications as indicated in the Construction Drawings.
- B. Cleaning and Inspection:
 - 1. All castings which have passed the required tests shall be thoroughly cleaned, inside and out, without the aid of acid or other liquid, and shall be subjected to careful inspection and hammer tests.
 - 2. The castings shall be of the dimensions indicated on the Contract Drawings and shall be free from sand or blowholes and cold shuts. No plugging or stopping of holes will be allowed. Casting lines and excess materials shall be ground smooth.

2.03 MANHOLE/HANDHOLE CABLE SUPPORTS

- A. Cable racks shall be surface-mounted, with stainless steel bolts, to ½ inch stainless steel anchor inserts, and installed vertically, approximately two feet apart on each wall, without blocking any duct bank openings for the new or future duct banks.
 - 1. The exact locations and quantity of cable racks depend upon the exact locations of the precast duct bank knockouts in each style of manhole, and shall be subject to review and acceptance by Caltrain.
 - 2. Cable racks shall be heavy duty non-metallic UL-listed glass reinforced polymer, Underground Devices Inc. or approved equal. The cable racks shall consist of:
 - a. A 36-inch-long stanchion that shall be attached to the manhole-wall in accordance with the manufacturer's recommendations and shall incorporate recessed bolt mounting holes and multiple arm mounting holes that are four (4) inches apart.
 - b. Adjustable arms that lock into the stanchion. Holes or slots shall be provided in the arms for cable wire ties. Cable rack arm lengths shall be appropriate for the manhole size and amount of cable being installed.
- B. The Contractor shall furnish manhole hardware, as specified herein, or approved equal. Drop-in anchors shall have a 1/2-13 thread, a rated pullout working capacity of 2,100 pounds and shall be made from either 303 or 316 stainless steel. A 316-stainless steel 1/2-13 hex head cap screw and a 316-stainless steel flat washer shall be used with each drop-in anchor.

2.04 WATERPROOFING

- A. Sealer for waterproofing exterior surfaces of manholes/handholes shall be a mineral colloid type asphalt emulsion, as manufactured by Hunt Process Company "Aqua Shield 124," or approved equal.

2.05 AGGREGATE BASE

- A. Crushed rock material for use as a base under manholes/handholes shall be in accordance with the specification requirements of coarse aggregates.

2.06 GROUT

- A. Non-shrinking, non-metallic grout shall be in accordance with ASTM C150 premixed compound capable of minimum compression strength of 4,000 pounds per square inch (psi).
- B. Water shall be clean and free from deleterious substances.
- C. Non-metallic non-shrinking grout shall be factory pre-mixed requiring only water addition in the field.
- D. Shrinkage, if any, shall be in accordance with ASTM C827.

2.07 UNDERGROUND DUCT WORK

- A. Unless otherwise indicated on the Contract Drawings, all underground duct sections and fittings shall be concrete-encased reinforced Thermosetting Resin Conduit (RTRC), standard wall, complying with NEMA TC 14 and UL 1684, Reinforced Thermosetting Resin Conduit (RTRC), or PVC. The RTRC and fittings shall be manufactured by Champion Fiberglass, FRE Composites, United Fiberglass of America, or approved equal.
- B. Concrete Encasement: Concrete encasement for these duct banks shall contain not less than 6½ sacks of Type I and Type II Portland Cement (ASTM C150), and shall have a compressive strength at age 28 days of not less than 2,500 psi. The maximum size of aggregate shall be ½ inch. The concrete shall be dyed a "Red" color with an approved concrete additive. Slump shall be between four (4) and six (6) inches.
- C. Separators: Conduit separators or spacers shall be non-metallic and of the type recommended by the conduit manufacturer.
- D. Direct buried conduits shall be heavy wall RTRC, or PVC.

2.08 BACKFILL

- A. Backfill material shall be in accordance with applicable parts of the Contract Documents.

2.09 MARKER

- A. Duct markers shall be located at the ends of all conduit runs except at structures, at approximately every 200 feet along the conduit run, and at each

change in direction of the conduit run. Markers shall be placed approximately two (2) feet to the right of the conduit when facing the longitudinal axis of the run and in the direction of the electrical load. Markers shall be made of 2,500 psi concrete, six (6) inch square or round section by two (2) feet long. The top edges of the marker shall have a 1/2-inch chamfer all around. The letter "D" with two arrows shall be impressed or cast on top of the marker. One arrow shall be located below the letter and shall point toward the ducts. The second arrow shall be located adjacent to the letter and shall point in a direction parallel to the ducts. The letter and the arrows shall be V shaped and shall have a width of stroke at least 1/4 inch at the top, and depth of 1/4 inch. The top of the markers shall be flush with the adjacent elevation of the paved or unpaved areas. Where the duct bank changes direction, the arrow located adjacent to the letter shall be cast or impressed with an angle in the arrow approximately the same as the angular change of the run.

PART 3 – EXECUTION

3.01 EXCAVATION AND BACKFILL

- A. Excavation and backfill shall be performed in accordance with Specification Section 31 50 00 Excavation Support and Protection.

3.02 INSTALLATION OF PRE-CAST MANHOLES AND HANDHOLES

- A. The Contractor shall install pre-cast concrete manholes and handholes as indicated on the Contract Drawings and shall be subject to review and acceptance by Caltrain.
- B. Prior to burial and installation, field-apply two (2) coats of concrete sealer to exterior surfaces of the manhole/handhole around the duct bank penetrations, conduit penetrations, frame, and field joints. Sealer shall be applied in accordance with the manufacturer's recommendations and must be of high quality to prevent water entry.
- C. Manhole/handhole cover and frame shall be installed as shown on the approved shop drawings. Cover frame shall be adjusted level and flush with finished grade.
- D. Weld manhole/handhole identification names to each cover. The identification names shall be recommended by the Contractor and approved by Caltrain prior to procuring manholes and handholes.
- E. Install a ground rod in each manhole and handhole so that eight inches of the ground rod protrudes above the concrete floor and seal around ground rod with grout finished to match floor. Bond ground rod to metallic cable supports, rigid steel conduit terminations, and other metallic components with #4/0 AWG bare copper cable per Section 34 31 16, TPF Grounding and Bonding. For manholes and handholes inside of the Traction Power Facilities' site perimeter, bond any metallic cable supports, rigid steel conduit terminations, and other metallic components with #4/0 AWG bare copper cable to the TPF ground grid.

3.03 INSTALLATION OF CONDUITS AND DUCT BANKS

- A. Conduits shall be installed as shown on the Contract Drawings. Duct bank configuration may be adapted to route obstructions such as underground utilities per Caltrain's approval; such adaptations may include rotating and fanning out of ducts.
- B. Conduits: Required depth of conduits from final grade to top of duct bank shall be 30 inches unless otherwise indicated. Contractor shall coordinate installation of conduits with Caltrain.
- C. The manufacturer's directions shall be followed in placing all conduits, fittings, supports and spacers, and in compensating for temperature effects.
- D. Spacers shall be placed at not greater than five (5) feet intervals on center. Use of metallic spacers will not be permitted. Spacer system shall be designed to support duct bank longitudinal reinforcing bars. Unless noted otherwise on the Contract Drawings, install one (1) #4 longitudinal reinforcement bar through the spacers at each of the four (4) outer corners of the duct bank, providing a minimum of one (1) inch of concrete cover over the bars.
- E. For concrete-encased duct banks, the concrete shall completely encase the duct bank without disturbing its vertical or horizontal alignment or damaging the conduits.
- F. The exposed surface of duct encasement concrete shall be floated smooth after placement, and an approved curing compound shall be applied in conformance with the concrete manufacturer's recommendations.
- G. Conduit terminations at manholes and handholes shall be fitted with end bells. The Contractor shall seal around all duct bank openings in the manhole and handhole walls with non-shrink grout and waterproofing sealer, as approved by Caltrain.
- H. At all stages of the work, the Contractor shall exercise care to prevent foreign materials from entering the ducts.
- I. Following installation, each conduit shall be thoroughly cleaned and then tested by the successful pulling of a brush and mandrel approved by Caltrain. The mandrel shall be not less than ¼ inch smaller than the inside nominal diameter of the conduit. The Contractor shall give Caltrain 24 hours notice prior to witnessing the cleaning and testing.
- J. A 1/8-inch nylon pull rope shall be installed in each conduit run and secured at each end.
- K. Marker tape shall be furnished in a continuous length without splices, and installed in one conduit of each duct run. The tape shall be secured at each end inside the manhole and handhole.
- L. All spare conduit terminations shall be plugged, using approved removable plugs.
- M. Warning tape is to be installed in the fill over all duct banks at a depth of approximately one (1) foot below finished grade. This tape shall be over the longitudinal centerline of the duct banks and shall have appropriate language

written on the tape that warns of the presence of cable duct banks below the tape and to not proceed with any excavation in the area.

- N. Pulling tension of cable shall not exceed the cable manufacturer's recommendations. Cable pulling calculations shall be provided by the Contractor.
- O. Connections to Manholes/Handholes: Duct bank envelopes connecting to manholes and handholes shall be flared to have an enlarged cross-section at the manhole/handhole opening dimensions by no less than twelve (12) inches in each direction. The perimeter of the duct bank opening in the manhole/handhole shall be flared toward the inside or keyed to provide for a positive interlock between the duct bank and the wall of the manhole/handhole. Vibrators shall be used when this portion of the envelope is poured to assure a seal between the envelope and the wall of the manhole/handhole.
- P. Partially Completed Duct banks: During construction, wherever a construction joint is necessary in a duct bank, without exception always prevent debris such as mud, sand, and dirt from entering ducts by providing suitable conduit plugs. Fit concrete envelope of a partially completed duct bank with reinforcing steel extending a minimum of twenty-four (24) inches back into the envelope and a minimum of twenty-four (24) inches beyond the end of the envelope. Provide one No. 4 bar in each corner, three (3) inches from the edge of the envelope. Secure corner bars with two No. 3 ties, spaced approximately four (4) inches apart. Restrain reinforcing assembly from moving during concrete pouring.
- Q. Conduit Plugs and Pull Rope: New conduit indicated as being unused or empty shall be provided with plugs on each end. Plugs shall contain a weep-hole or screen to allow water drainage. Provide a plastic pull rope having thirty-six (36) inches of slack at each end of unused or empty conduits.
- R. Duct bank and conduits shall slope down toward the manhole and handhole wall entry to allow ingress of water into the manhole/handhole and prevent collection of water inside the conduit.

END OF SECTION

SECTION 34 31 26

TPF BATTERIES AND ACCESSORIES

PART 1 – GENERAL

1.01 SCOPE

- A. The work of this Section consists of manufacturing, factory testing, and delivering station batteries and all associated equipment necessary to supply control and miscellaneous DC emergency power for Traction Power facilities. The batteries shall be of the Absorbed Glass Mat (AGM), Valve Regulated Lead Acid (VRLA) type for all locations except for the Traction Power Substations and PG&E Metering Enclosures which shall be Vented Lead Acid (VLA) type or Nickel Cadmium (Ni-Cad).
- B. The station battery systems shall provide 125 VDC nominal control power to TPF switchgear and control house equipment, and exterior power and control equipment including motor operated disconnect switches and the SCADA system.
- C. Each system shall consist of battery charger, battery bank, a battery rack, insulating mat, DC distribution panelboard, battery disconnect switch, and all equipment and materials necessary for a complete installation and subsequent system maintenance activities.
- D. All equipment in WPCs shall comply with seismic Zone 4 requirements.
- E. All equipment in traction power substations and paralleling/switching stations shall comply with IEEE 693 and seismic Zone 4 requirements.
- F. For PG&E Battery Requirements from PG&E Interconnection Handbook at Traction Power Substation, see attached Appendix T. These requirements shall apply to all Traction Power Substations 25 kV Switchgear Enclosures and PG&E Metering Enclosures.

1.02 REFERENCE STANDARDS

- A. American National Standards Institute (ANSI):
 - 1. Z358.1 Emergency Eye Wash and Shower Equipment
- B. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. 446 IEEE Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications
 - 2. 450 IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications
 - 3. 484 IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications

4. 485 IEEE Recommended Practice for sizing Large Lead Storage Batteries for Generating Stations and Substations
 5. 1106 IEEE Recommended Practice for Installation, Maintenance, Testing, and Replacement of Vented Nickel-Cadmium Batteries for Stationary Applications
 6. 1187 IEEE Recommended Practice for Installation Design and Installation of Valve Regulated Lead-Acid Storage Batteries for Stationary Applications
 7. 1188 IEEE Recommended Practice for Maintenance, Testing, and Replacement of Valve- Regulated Lead-Acid (VRLA) Batteries for Stationary Applications
 8. 1189 Guide for Selection of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications
- C. National Electrical Manufacturers Association (NEMA):
1. 250 Enclosure for Electrical Equipment (1,000 Volts Maximum)
 2. AB3 Molded-Case Circuit Breakers and Their Application
 3. FU 1 Low-Voltage Cartridge Fuses
 4. PB 1 Panelboards
 5. PE 5 Utility Type Battery Chargers
- D. National Fire Protection Association (NFPA):
1. 70 National Electrical Code
- E. Underwriters' Laboratories, Inc (UL):
1. UL 67 Panelboards
 2. UL 489 Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures

1.03 RELATED SECTIONS

Related requirements are included in, but not limited to, the following Sections:

- A. 34 31 03 - General Traction Power Requirements
- B. 34 31 13 - Basic Traction Power Materials and Methods
- C. 34 31 89 - TPF Enclosures

1.04 ACCEPTABLE MANUFACTURERS

- A. All components of each system shall be supplied by one manufacturer. Battery components shall be manufactured by GNB Industrial Power, or approved equal.

1.05 SUBMITTALS

- A. Submit the following in accordance with Section 34 31 03:
 1. Manufacturer's product description, catalog data, and information.
 2. Manufacturer's arrangement, wiring, and detail drawings.
 3. Design calculations for battery and battery charger sizing for each type of substation, switching station, paralleling station, and wayside power cubicle that is to be delivered.
 4. Manufacturer's recommended charger setting for each type of substation, switching station, paralleling station, and wayside power cubicle that is to be delivered.
 5. Operating and maintenance manual including a spare parts list.

1.06 WARRANTY

- A. Batteries shall have a warranty of one (1) year from the date the battery is placed in service and an additional warranty of 10 years, pro rata, to deliver not less than 80 percent of its rated capacity.

PART 2 – PRODUCTS

2.01 RATINGS

- A. The input voltage at each TPF shall be 120/240 V, single phase, 60 Hz; the nominal station battery system output voltage shall be 125 Volts DC.
- B. Station battery system capacity (Ampere and Ampere-hour ratings) shall be determined by the Contractor based on the load cycle of the equipment in each TPS, PS and SWS and typical wayside power cubicle as defined by IEEE Std 485. The battery design and installation shall be in accordance with the applicable IEEE standard based on their respective type. Contractor shall establish the required capacity in rated ampere hours for a 8-hour discharge rate to minimum 1.75 V per cell at 77° F.

2.02 BATTERIES

- A. The battery and its associated charger shall be connected in parallel. The charger, in addition to charging the battery, shall carry the continuously connected DC load via the DC panelboard. The battery shall supply the remainder of the heavy short-time current demands. When the AC supply to the charger is interrupted, the battery shall supply the required power for the specified load duty cycle.
- B. Batteries shall be of the types indicated in Section 1.1.A type with a life

expectancy of at least 20 years and be low maintenance. Batteries shall be designed for float service. The battery life expectancy for the Wayside Power Cabinets (WPCs) shall be a minimum of 10 years, and the Paralleling Stations (PSs) and Switching Stations shall be 15 years minimum.

- C. Batteries shall consist of a sufficient number of cells to provide a nominal output floating voltage of 135 V.
- D. Battery capacities shall be adequate for the following load duty cycle over a period of 8 hours from a fully charged state with the battery charger out of service:
 1. Normal continuous demand of station ancillary loads including relays, indicating lamps, control panel, and supervisory control circuits.
 2. After 8 hours, close and trip either one 115 kV AC circuit breaker or one motor-operated disconnect switch (MOD).
 3. After 8 hours, close in sequence or trip all the 25 kV AC switchgear circuit breakers.
- E. The batteries shall be able to support at least three operating cycles (where trip and close operation constitute one cycle) of all circuit breakers simultaneously.
- F. Each positive and negative cell assembly shall be designed for the required battery duty and a long-life cycle. Cell elements shall be supported from projections in the bottom of the cell container or from the cover.
- G. Cells shall be provided with inter-cell connectors. Batteries shall be provided with terminal plates and lugs as required. Connectors, plates, and lugs shall be lead-plated solid copper.
- H. Manufacturer's recommendations for installation and charging settings shall be executed with the approval of Caltrain.

2.03 BATTERY RACKS

- A. Battery racks shall be provided with insulating plastic strips to cover all supports, hold downs, and restraining rails that are in contact with the battery cells. The exposed perimeter of the battery racks shall be covered with removable non-metallic acid-resistant barriers to preclude storage of foreign metallic objects.
- B. For WPCs, battery racks shall comply with seismic Zone 4 requirements.
- C. For traction power substations and paralleling/switching stations, battery racks shall comply with IEEE 693 and seismic Zone 4 requirements.
- D. Racks shall be treated with acid-resistant finish paint coat.

2.04 INSULATING MAT

- A. Electrolyte resistant plastic mat shall be provided under each battery rack,

extending not less than 12 inches outside the rack.

2.05 NAMEPLATES

- A. Each battery cell container shall be marked with the following information:
 - 1. Manufacturer's name.
 - 2. Month and year of manufacture.
 - 3. Cell type.
 - 4. Ampere-hour capacity.

2.06 ACCESSORIES

- A. One set of the following accessories shall be provided for each battery system:
 - 1. Cell lifting sling and spreader.
 - 2. Battery log book.
 - 3. Quart of terminal grease.
 - 4. Set of special insulated tools. The provided tool set shall include all the required tools to install, disassemble, torque, as per the manufacturer's requirements.
 - 5. Set of cell identification numbers.
 - 6. Main battery fuses and holders – Fuses shall comply with NEMA FU 1 and shall provide short circuit protection for the battery and main cables to the DC distribution panelboard. Fuses shall be mounted adjacent to the battery rack, and shall be double-pole, pullout fuse type.

2.07 BATTERY CHARGERS

- A. Chargers shall be Float Battery type with two (2) phase input and shall be microprocessor controlled. Microprocessor control shall include the ability to communicate charger status to the SCADA system via remote I/O. Voltage input is to be verified per location.
- B. Battery charger enclosure shall meet seismic Zone 4 requirements and NEMA 250, Type 1 specifications. Enclosure shall be provided with a hinged front panel complete with two-point latches, minimum. Enclosure shall be louvered.
- C. Battery chargers shall be rated as follows:
 - 1. Capacity: In accordance with its associated battery size and continuous DC load.
 - 2. Recharging: Shall be able to recharge the battery at 2.25V per cell to at least 85 percent of the battery capacity in 8 hours, maximum.

3. Output current: In accordance with its battery size and continuous DC load.
 4. Regulation: ± 1 percent of output DC voltage over its complete load range with ± 10 percent variation of input AC voltage. Temperature compensated for VRLA batteries.
 5. Current Limiting: Adjustable from 90 to 115 percent; factory set at 110 percent of output nominal current rating.
- D. Each battery charger shall be furnished with the following:
1. One (1) DC voltmeter, 0 to 200 V.
 2. One (1) DC ammeter, range as applicable.
 3. One (1) DC input pilot light marked AC POWER ON.
 4. One (1) selector switch two positions marked FLOAT and EQUALIZE.
 5. Two (2) ground detection alarm relays, positive and negative, for local and remote supervisory annunciation.
 6. One (1) AC input molded-case circuit breaker, NEMA AB 1.
 7. One (1) DC output molded-case circuit breaker, NEMA AB 1.
 8. One (1) equalizing time charger, 0 to 72 hours, to terminate a manually set adjustable equalizing charge of 2.25 V per cell.
 9. One (1) DC failure alarm relay for local and remote supervisory annunciation.
 10. One (1) AC failure alarm relay for local and remote supervisory annunciation.
 11. Space heaters, as indicated.

2.08 DC DISTRIBUTION PANELBOARDS

- A. DC panelboards shall comply with the requirements of NEMA PB 1, be certified to UL 67, and shall be suitable for 2-wire, 125VDC ungrounded power distribution service. Panelboard shall be equipped with main and branch circuit breaker type disconnects complying with NEMA AB 1.
- B. Panelboards shall be surface mounted, dead-front type, housed in a NEMA Type 1 steel enclosure with hinged front cover, lockable handle, and two-point latch, minimum.
- C. A moisture resistant circuit identification chart shall be furnished and attached to the inside face of the cover.

- D. The Contractor shall establish the required current rating of the control power distribution panelboards for each traction power substation, switching station and paralleling station. Panelboards shall be furnished with main incoming terminals and disconnects for separate connection of battery and battery charger supplies. Branch circuit breakers shall be 2-pole 100 A frame size with 10,000 A interrupting rating, minimum.
- E. Panelboards shall be furnished with the required number of branch circuit disconnects based on the following control power distribution requirements:
 - 1. High-voltage motorized disconnect switch
 - 2. 115 kV circuit breaker (for TPS only)
 - 3. 25 kV switchgear assembly
 - 4. Each traction power transformer; each switching autotransformer; each paralleling autotransformer
 - 5. Each 25 kV motorized disconnect switch
 - 6. Control panel and relay
 - 7. Supervisory control remote terminal unit
 - 8. Communications Equipment Cabinet
 - 9. Four (4) spares
 - 10. All additional circuits as shown on the DC panel drawings

2.09 VOLTAGE MONITORING RELAY

- A. A voltage monitoring relay manufactured by Potter and Brumfield type KRPA/11DN110 or Agastat relay, or approved equal, device 27DC-B shall be provided to monitor total loss of substation DC control power supply. The relay shall be equipped with form "C" contact to be wired to the supervisory control interface terminal cabinet for remote supervisory annunciation. The relay shall be housed in a NEMA 1 enclosure and installed adjacent to the DC distribution panelboard.
- B. An analog voltage monitoring transducer shall measure the DC voltage and provide the measurements to SCADA.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Install battery and specified equipment within each traction power facility enclosure: secure, plumb, and level and in true alignment with related adjoining work.
- B. Install supporting members, fastenings, framing, hangers, bracing, brackets,

straps, bolts, angles, as required to set and rigidly connect the work.

- C. Battery cells shall be assembled on the battery racks, filled with electrolyte, and given an equalizing charge, following the installation of the prefabricated traction power facility at the site, but before the start of field testing.
- D. Battery rack, battery charger, insulating mat, and associated devices shall be installed as shown on the approved shop drawings.
- E. The battery and battery charger shall be placed in service in accordance with the manufacturer's recommendations.
- F. Battery inter-cell connectors shall be assembled, torqued, and tested per the battery manufacturer's specifications. The completed battery shall have the inter-cell connectors tested with a micro ohmmeter and values recorded. Any inter-cell connector that fails the manufacturer's specified requirement by twenty (20) percent shall be disassembled, cleaned, prepared, reassembled, and re-tested until it tests within the specified limits.
- G. Battery shall be tested in accordance with 34 31 93 TPF Energization Testing and Training. All of the manufacturer's recommended testing must also be performed and recorded.

END OF SECTION

Appendix T: BATTERY REQUIREMENTS FOR INTERCONNECTION TO PG&E SYSTEM

The purpose of this document is to ensure safety and reliability of Pacific Gas and Electric Company and its customers who will or plan to interconnect to PG&E system. The requirements made here will ensure that the system operates as designed.

It is required on new installations, any protection changes (including like-for-like) or upon request by PG&E that the following documentation be provided to PG&E for review and approval by Substation Project Engineering Department:

1. Type of utility grade Battery (Flooded lead acid or NiCd). Monoblock (multiples cells in a jar) batteries from C&D, EnerSys, BAE, or other approved vendors will be acceptable. Car, deep cycle marine batteries and Sealed Batteries (VRLA) are not acceptable. Battery racks must be designed to withstand loading based on IEEE 693 – High Seismic Zone. UBC Certification is not acceptable. See table on page AT-3 for approved battery make and models.
2. Detailed information of load including continuous and momentary. No minimum load requirement-Smallest flooded acid may be the limitation.
3. Battery sizing calculation based on [IEEE Std 485-1997](#) (IEEE recommended Practice for Sizing Large Lead Storage Batteries for Generating Stations and Substations) or [IEEE Std 1115-2000](#) (IEEE Recommended Practice for Sizing Nickel-Cadmium Batteries for Stationary Applications) and minimum 8 hours discharge rate using manufacturer software (to ensure proper discharge curve is used) using aging factor of 1.25 and design margin of 1.1 to be clearly shown on the calculation. Charger sizing calculation based on battery size with recharge time of 12 hours assuming charger will support the continuous load and recharging of the battery at the same time.
4. When battery is installed, proof of discharge testing (3 hour load testing is typical) to ensure battery has the capacity to support the load and trip, per [IEEE Std 450-2010](#) (Voltage measurements should be taken every 15 minutes throughout the testing).
5. Document showing what kind of maintenance will be done (Monthly, Quarterly, and Yearly, etc.) Batteries connected to the Bulk Electric System (BES) must meet PRC-005 and TPL-001 requirements. Entities may be required to show proof of compliance upon request.
6. Monitoring of minimum battery low voltage by separate voltage relay or through charger and provide critical alarm to SCADA or monitoring system. An audible and visual alarm is required for 24/7 on-site monitoring.
7. Along with documentation of items 1-6; Form AT-1 (below) must be completed and submitted by the customer to Substation Project Engineering Department for approval.

Because of serious reliability, safety and reduced life concerns with sealed (also called Valve Regulated Lead Acid – VRLA) batteries industry-wide, PG&E has stopped the use of sealed batteries in substation or any switchgear installations or interconnection using these batteries. Flooded lead acid (calcium, antimony) and Nickel-Cadmium (NiCd) are the only batteries acceptable in these installations.

Switchgear compartments typically see very high temperatures, and if sealed batteries are used they will dry out in less than a few years causing safety and reliability concerns along with not having the capability to trip breakers. A side by side comparison of IEEE Std. 450-2002 Section 5.2.3 (IEEE Recommended Practice for Maintenance, Testing and Replacement of Vented lead acid batteries for Stationary applications –also referred as Flooded batteries) and IEEE Std 1188-1996 Section 5.2.2 Subsections a, b & c. (IEEE Recommended Practice for Maintenance, Testing and Replacement of Valve-regulated batteries for Stationary application- also referred as VRLA) clearly demonstrates that VRLA requires Quarterly ohmic resistance testing compared to yearly ohmic testing for flooded batteries. Experience industry wide indicates problem with doing ohmic tests on VRLA because of the design of battery and trying to make connections to the terminals and interconnecting hardware. Even if ohmic resistance reading is not done on flooded battery, the failure modes can be detected by other means whereas with VRLA eliminating this test could cause dryout condition and ultimately catastrophic failure. In hot environment VRLA would require charger compensation as well as monitoring which is expensive and still not proven to be adequate. In the telecommunication industry there are presently trials under way for system wide replacements of VRLA with Flooded or NiCd batteries. PG&E recommends use of NiCd batteries in switchgear cubicle because of better performance under extreme temperatures. Flooded batteries can also be used in switchgear.

Additional reasoning for not using VRLA in substation as pointed out by IEEE Battery working group Chairman in the recent paper published in IEEE. “Summarizing the issue for VRLA batteries”, there is a considerable risk involved in installing a single VRLA string in a substation. If parallel strings are installed, to operate reliably, they must be redundant, either by design or by a sufficient degree of conservatism in the sizing calculation. In building in redundancy, however, the main aim of reducing battery costs is compromised. Despite the early claims of maintenance-free operation, VRLA batteries require considerable surveillance and testing to maintain a high degree of reliability, IEEE Std 1188-1996 [2] recommends quarterly internal ohmic measurements and annual discharge testing of VRLA. These measures are largely ignored by the telephone operating companies because of their low loads and use of parallel strings, as detailed above. In substation operation, however, these practices are doubly important because of the higher currents involved”.

PG&E Approved Interconnection Batteries ^{1,2}		
Type	Manufacturer	Model Line
Vented or Flooded Lead Acid (VLA)	C&D	DCU
		DJ
		JC
		KCR
		LCY
		LCR
	Alcad	LSe
		SGL/SGH
		SD/SDH
	BAE	OGi
		OPzS
	Energys	OPzS
		Powersafe CC
		Powersafe EC
		Powersafe FC
		Powersafe GC
	Powersafe Plante'	
	SBS	STT
		SR
	Hoppecke	GrOE
		OSP
		OPzS
	GNB	MCX/MCT/H1T
		NCX/NCN/NCT
PDQ/ T-Bloc		
Nickel Cadmium (Ni-Cad)	Alcad	LE
		M
		H
	SBS	KP
	Energys	RH
		RM
		RL
		VGM
	VGL	

¹ **List is not exclusive**, other battery manufactures and model lines must be submitted for review

² Multiple cells per jar or block types of any models above are acceptable

FORM AT-1, Third Party Interconnection Battery Information Sheet and Acceptance Document

Section 1: To be completed by Customer while providing all pertinent information and documentation for review based on Appendix T of the TIH or PG&E document TD-2999B.

Project Name: _____ **Site:** _____ **Date:** _____

Type of Interconnection/project and Voltage Class: _____
(Transmission, Distribution, Primary Service, Relay Replacement, etc.)

1A) - Battery

Is Battery Flooded type or Sealed Type	
Battery Manufacturer	
Battery Size.	
Battery Model No.	

1B) Charger

Charger Size	
Charger Model No.	

1C) Rack

Is Rack Certified for IEEE 693, High Seismic Zone (UBC Certification is not accepted) –	
Rack Manufacturer and Model No.	

2- List of DC Loads

Is list and quantity of DC Loads included with the Submittal?	
---	--

3-Battery Sizing Calculation

Is Battery sizing sheet based on IEEE 485-1997 or IEEE 1115-2000 included with the Submittal.	
---	--

4 –Proof of Discharge Testing

Is proof of Discharge Testing included with this Submittal	
--	--

5 –Maintenance

Are maintenance schedule and procedure included with this Submittal	
---	--

6 – Battery Low Voltage Monitoring

Are details included with this submittal for 24/7 monitoring of Low DC Voltage. – Please specify Yes or No Remote monitoring is required for unmanned Sites	
--	--

Section 2: To be completed by PG&E Substation Engineering Department

**FORM AT-1, Third Party Interconnection Battery Acceptance
Document**

Date: XX/XX/XXXX

Name of Customer:

JO#:

Distribution engineer or PM:

Reviewed by:

Item 1: Type of Utility Grade Battery –

Battery Type:

Rack Type:

Charger Type:

Item 2. Detailed Load Information –

Item 3. Battery & Charger Sizing Calculations –

Item 4. Proof of 3hr-Discharge Testing –

Item 5. Maintenance Procedures –

Item 6. Monitoring of Minimum Battery Voltage –

(Ensure battery DC low voltage is monitored as this will be verified during the Pre-Parallel inspection).

Thank you,

(Engineer who reviewed Info)
Substation Project Engineering

SECTION 34 31 29

TPF AUXILIARY POWER SYSTEMS

PART 1 – GENERAL

1.01 SCOPE

- A. This Section specifies the furnishing and installation of auxiliary 120/240 VAC power systems for use in the control house/ switchgear enclosures of the Traction Power Facilities (TPF) such as a prefabricated-type Traction Power Substations (TPS), Switching Station (SWS), Paralleling Station (PS), or Wayside Power Cubicles (WPC).
- B. The Contractor shall provide an auxiliary power system consisting of three (3) separate 120/240 VAC power supply sources as configured on the Contract Drawings:
1. TPF Primary Auxiliary Power shall be derived from a single-phase, 75 KVA, 27.5kV- 120/240V pad-mount transformer connected to the substations AT Feeder Bus. The transformer secondary is connected to the "normal" pole of the automatic transfer switch (ATS) located in the TPF.
 2. Switching Station (SWS) and Paralleling Station (PS) primary auxiliary power shall be derived from a single-phase, 75 KVA, 27.5kV-120/240V pad-mount transformer connected to the load side of an AT Feeder circuit breaker.
 3. TPF Alternate Auxiliary Power shall be a 120/240V source delivered from a PG&E service drop. The auxiliary power shall be connected to the "emergency" pole of the automatic transfer switch located in the TPF.
 4. The load side of automatic transfer switch shall be connected to the "normal" pole of the Manual Load Transfer Switch (MLTS).
 5. TPF Emergency Auxiliary Power shall be derived from a portable diesel generating set (not in contract). The contractor shall furnish all equipment, wiring, and components needed to connect a portable generator to the TPF. The generator connection shall be connected to the "emergency" pole of the manual transfer switch (MLTS) located in the auxiliary power control cabinet.
 6. The primary and backup 120/240 VAC power supply circuits, associated automatic transfer switch (ATS), manual load transfer switch (MLTS), and downstream distribution equipment including auxiliary power control panel, 120 VAC distribution panel, as indicated schematically on the Contract Drawings.
- C. The Contractor shall be responsible for the final sizing, detailed design and coordination of the auxiliary power system to satisfactorily operate the substation equipment installed under this Contract.

- D. Testing of TPF auxiliary power systems is specified in Section 34 31 76, TPF Testing and Commissioning.

1.02 REFERENCE STANDARDS

All equipment furnished under this Section shall be in accordance with the latest applicable standards of the IEEE, ANSI, NFPA, NEMA, ICEA, ASTM, UL, and National Electrical Code with regard to material, design, construction and testing. The standards applicable shall include, but not be limited to, the following:

- A. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. C37.21 IEEE Standard for Control Switchboards
 - 2. C37.90 Relays and Relay Systems Associated with Electric Power Apparatus
 - 3. C62 IEEE Surge Protection Standards Collection
- B. American National Standards Institute (ANSI):
 - 1. C57.12.70 Terminal Markings and Connections for Distribution and Power Transformers
- C. National Electrical Manufacturers Association (NEMA):
 - 1. AB 1 Molded-Case Circuit Breakers, Molded-case Switches, and Circuit Breaker Enclosures
 - 2. AB 3 Molded Case Circuit Breakers and Their Application
 - 3. ICS 6 Industrial Control and Systems: Enclosures
 - 4. ICS 10 AC Transfer Switch Equipment
 - 5. LS-1 Low Voltage Surge Protection Devices
 - 6. PB 1 Panelboards
 - 7. TR 1 Transformers, Regulators and Reactors
- D. Underwriters Laboratories (UL):
 - 1. 1008 Transfer Switches
 - 2. 1449 Transient Voltage Surge Suppressors

1.03 RELATED SECTIONS

Related requirements are included in, but not limited to, the following Sections:

- A. 34 31 03 - General Traction Power Requirements

- B. 34 31 13 - Basic Traction Power Materials and Methods
- C. 34 31 76 - TPF Testing and Commissioning
- D. 34 31 89 - TPF Enclosures
- E. 34 31 16 - TPF Grounding and Bonding

1.04 SUBMITTALS

Submit the following in accordance with Section 34 31 03:

- A. Manufacturer's descriptive literature, catalog data and other pertinent information sufficient to clearly demonstrate compliance with the Contract Documents for all components of the TPF Auxiliary Power Systems.
- B. PG&E service auxiliary power load calculations:
 - 1. In units of kW and kVAR, or in kVA with load power factors indicated.
 - 2. For both winter and summer operation.
- C. Detailed drawings shall include dimensioned outline drawings of all major equipment and devices indicating their location relative to other equipment. Include dimensioned floor plans and front, top, and section views.
- D. Relay and metering diagrams and schematic wiring and internal connection diagrams showing all power and auxiliary circuits, protective devices, transducers, meters and contact development.
- E. Bills of Material and nameplate schedules keyed to the submitted drawings.
- F. Complete descriptions of all protective devices including device coordination (TCC) curves, setting procedures and instruction manuals.
- G. After approval of schematic diagrams, submit interconnection and wiring diagrams.
- H. Certified design test reports and test certificates.
- I. Production test schedule, certified test reports, and test certificates.

PART 2 – PRODUCTS

2.01 PG&E OR OTHER UTILITY PROVIDER OF 120/240V SERVICE

- A. The Contractor shall obtain one standard commercial 120/240 V service drop from the Utility provider for each TPS, PS, SWS, and WPC for the TPF auxiliary power (See sub-para 1.1 B in this connection). The Contractor shall be responsible for all coordination with the utility provider for these services, and for their installation. The Contractor may use these services for temporary power prior to TPS, PS, SWS, and WPC commissioning.

- B. The service Ampere ratings shall be determined by the Contractor as described above; however, in no case shall the services be less than 400 A.
- C. The 120/240 V services shall enter each TPF via underground duct bank as shown on the Contract Drawings.

2.02 120/240V MANUAL LOAD TRANSFER SWITCH ASSEMBLY (MLTS)

- A. The MLTS assembly shall enable Caltrain to connect a portable 120/240 V generator to the TPF auxiliary power system in an emergency.
- B. The Contractor shall design the assembly to provide the functionality required and furnish, install, and test all associated components.
- C. The MLTS shall be housed in the Auxiliary Power Control Cabinet.
- D. Transfer switch shall be positively interlocked to prevent simultaneous closing of both sources. Main contacts shall be mechanically locked in position in both normal and alternate positions.
- E. Transfer switch shall be capable of being operated under full rated load conditions. The operation shall be accomplished by a permanently attached manual operator.
- F. The MLTS assembly components shall include:
 - 1. Flanged generator inlet, NEMA configuration to match Caltrain generators, 400 A, 120/240 VAC, UL listed for outdoor use.
 - 2. Associated electrical cables and raceways

2.03 SUBSTATION LOW-VOLTAGE AC PANELBOARD (ACPP)

- A. Provide a wall-mounted, dead front, UL Listed 120/240VAC low-voltage ac panelboard in each TPS, PS, SWS, and WPC that accommodates all required circuits and necessary accessories for power and control.
- B. Panelboard shall comply with Section 26 24 16, Panelboards. Minimum requirements for this panelboard are as follows.
 - 1. Main breaker, 350 A (Contractor to confirm rating)
 - 2. 42 branch circuits, with unrestricted mounting locations
 - 3. Circuit directory holder located on inside of panelboard door
 - 4. ANSI 61 gray polyester powder coat paint
 - 5. Integral transient voltage surge suppressor (TVSS):
 - a. 125% maximum continuous operating voltage (MCOV)

- b. 65 kA symmetrical withstand and UL 1449, 400 V suppressed voltage rating, per mode
 - c. Controls, instruments and 120/240V manual transfer switch shall be individually mounted and fully front accessible
 - d. Status indicating lights
- C. Line and load side 120/240 V circuit breakers.
- 1. Molded case type, 2-pole, 600VAC, certified for use within enclosures at 100 percent rated current.
 - 2. Frame, trip and interrupting ratings to be determined by the contractor based on Contractor's approved load analysis.
 - 3. Mounted on inside of cabinet door with toggle handle protruding through door, so that breaker can be operated and interlocked by personnel standing in front of closed cabinet.
- D. Meters and Instruments
- 1. AC analog voltmeter: 0-150 V, door-mounted.
 - 2. AC analog ammeter: 400 A, door-mounted.
 - 3. Current transformer: window type, 300:5 ratio, C10 accuracy class.
 - 4. Contractor to confirm all current ratings or modify, as required.
- E. Relays
- 1. AC undervoltage monitor relays, Device Nos. 27AUX-1, 27AUX-2 and 27AUX-3: 120 V phase undervoltage indication and annunciation, adjustable drop-out range of at least 80 to 100 V, 10 A DPDT contacts, LED output and contact status indication, one relay on each line and load side 240 V circuit.
 - 2. Battery charger failure, instantaneous relay circuit, device No. 27BC
 - 3. Battery charger failure, 8-hour time delay relay circuit, device No. 27BT
 - 4. APCC 125 VDC control power undervoltage relay, device No. 27DC-APCC
 - 5. Control house intrusion detection alarm relay circuit, device No. IDX
 - 6. Control house smoke alarm detection relay circuit, device No. SDX

2.04 120/240V AUTOMATIC TRANSFER SWITCH (ATS)

- A. The ATS assembly shall automatically transfer between the auxiliary power primary and alternate power sources. This operation shall provide the TPF with uninterrupted auxiliary power system in the event one of the two (2) sources

becomes de-energized.

- B. The Contractor shall design the assembly to provide the functionality required and furnish, install, and test all associated components.
- C. The ATS shall be mounted on the side of the yard pad mounted auxiliary transformer.
- D. Provide microprocessor-based indication unit with communication package, unit shall send ATS status, alarms and load data to the TPF SCADA system.
- E. Transfer switch shall be positively interlocked to prevent simultaneous closing of both sources. Main contacts shall be mechanically locked in position in both normal and alternate positions.
- F. Transfer switch shall be capable of being operated under full rated load conditions. The operation shall be accomplished by a permanently attached manual operator, or by integrally mounted pushbuttons.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. For ATS and MLTS installation refer to section 34 31 32 – 3.1.

3.02 TESTING

- A. For ATS testing refer to section 34 31 32 – 3.1.
- B. Perform MLTS acceptance and commissioning tests in accordance with approved test procedures.

END OF SECTION

SECTION 34 31 30

MEDIUM-VOLTAGE TRANSFORMERS

PART 1 – GENERAL

1.01 DESCRIPTION

- A. This Section includes the specifications for Medium-Voltage Transformers, which are furnished at Traction Power Substations (TPS), Paralleling Stations (PS), and Switching Stations (SWS).
- B. The Medium-Voltage Transformers shall be pad mounted rated at 27.5 kV primary, 1-phase, 60 Hz, 75 kVA.

1.02 RELATED SECTIONS

Related requirements are included in, but not limited to, the following Sections:

- A. 34 31 03 - General Traction Power Requirements
- B. 34 31 13 - Basic Traction Power Materials and Methods
- C. 34 31 11 - Substation Control Cabinet Equipment
- D. 34 31 29 - TPF Auxiliary Power Systems
- E. 34 31 76 - TPF Testing and Commissioning

1.03 REFERENCE STANDARDS

- A. Conform to these specifications and to the applicable requirements of the latest edition of the following codes, regulations and standards:
 - 1. Institute of Electrical and Electronic Engineers (IEEE)
 - 2. American National Standards Institute Standards C57.12.00, C57.12.20, C57.12.22 (provisions except 46 kV class is required), & C57.12.90
 - 3. American Society of Testing and Materials Standards D3487, D3612, D877, & D1816
 - 4. National Electrical Manufacturers Association Standards TR1
 - 5. National Fire Protection Association NFPA 70
 - 6. IEEE National Electrical Safety Code C2 and Standard Symbols for Units of Measurements 260.1
- B. All other applicable laws, ordinance and requirements of the local agencies and utility companies having jurisdiction.

- C. In the event of any conflicts in the provisions stipulated in the referenced codes, regulations or standards and the specifications, the most stringent provision, as determined by the Project Manager, shall govern.

1.04 SUBMITTALS

- A. Provide the services of a qualified electrical detailer to perform the submittals.
- B. Submit shop drawings indicating outline dimensions, connection and support points, weight, specified ratings and materials. Submit details of mounting arrangements, details of mounting hardware, and sketches in plan and elevation showing minimum recommended clearances.
- C. Submit electrical characteristics and certified copies of test reports indicating standard model design tests and options.
- D. Submit product data for each component and accessory specified.
- E. Submit bill of materials, manufacturer's instructions for installation, operation and maintenance and warranty data. Include procedures for sampling and maintaining fluid, cleaning unit, and replacing components.
- F. Submit operation and maintenance data and recommended spare parts list.
- G. Submit factory and field test procedures and blank test forms for review and approval. During the construction phase, submit completed test reports, prototype test reports first.

1.05 STORAGE AND HANDLING

- A. Off load the equipment per the manufacturer's instructions.
- B. Upon arrival, inspect for any shipping damage. Note any damage on the accompanying paperwork, and report to the manufacturer's local representative what was delivered damaged.
- C. Store and protect products from moisture and debris by storing in a clean, dry heated space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect the unit substation components. Provide space heating for the transformers, should it be required in accordance with the manufacturer's recommendations and these specifications.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work include, but are not limited to, the following:
 - 1. ABB
 - 2. Cooper Power Systems

3. VanTran Industries
4. R.E. Uptegraff Manufacturing, Co
5. Or approved equal

2.02 MEDIUM VOLTAGE TRANSFORMERS

A. Pad Mounted Type:

1. The transformer(s) shall be pad mounted type, self-cooled, oil filled suitable for installation at the traction power facilities.
2. The average temperature rise of the windings, measured by the resistance method, shall be 55° C when the transformer is operated at rated kVA output in a 40 degrees C ambient. The transformer shall be capable of being operated at rated load in a 30 degrees C average, 40 degrees C maximum ambient, as defined by ANSI C57.12.00 without loss of service life expectancy.
3. The high and low voltage compartments shall be located per manufacturer's standard, separated by a steel barrier. When facing the transformer, the low voltage compartment shall be on the right. Terminal compartments shall be full height, air-filled, with individual doors. The high voltage door fastenings shall not be accessible until the low voltage door has been opened. The high voltage terminations and equipment shall be dead front and conform to ANSI C57.12.26. The high voltage compartment shall be suitable for terminating two full rated high voltage underground cables with indoor type terminations.

B. Standard Accessories

The following accessories shall be provided as standard on all pad mounted transformers:

1. Tamperproof removable bolted cabinet with three-point latching lift off doors with stainless steel hinges and open bottom for conduit or cable entrance
2. Tamperproof removable cover for access to bolted on inspection plate
3. Welded on lid
4. Lifting hooks
5. Transformer base with provisions for rolling
6. Two each low voltage bushings with NEMA 4-hole spade terminals. The low voltage bushings shall be molded epoxy, and provided with blade-type spade terminals with NEMA standard hole spacing arranged for vertical take-off.
7. One each low voltage neutral bushing with NEMA 4-hole spade terminal

and external grounding strap. The low voltage neutral shall be an insulated bushing, grounded to the tank by a removable ground strap.

8. Neutral ground boss
9. Tank grounding bosses – each compartment
10. Diagrammatic corrosion resistant stainless steel nameplate
11. One each 46 kV high voltage wall mounted distribution type bushing with mechanical eye bolt connector, and one each 15 kV bushing with 2-hole spade connector, provide Glastic barriers on each side of compartment walls. The bushing that is connected to ground shall be distinctly marked as “grounded bushing.” Bushings shall be externally clamped and front removable.
12. 1-inch filling plug
13. 1-inch drain plug, drain valve and sampler
14. Automatic pressure relief valve
15. Externally operated no-load tapchanger
16. Transformer windings all copper wound
17. 46 kV class lightning arresters mounted in medium voltage compartment
18. Non-PCB mineral oil filled coolant conforming to ASTM D3487, Type II (quote as option- high flash point biodegradable oil coolant conforming to ASTM D6871)
19. Radiators, as required
20. Bottom of transformer under-coated to prevent corrosion
21. Stainless steel enclosure
22. Rated for use in UBC Zone 4 seismic environment.

2.03 GENERAL REQUIREMENTS

- A. Equipment shall be suitable for continuous operation under the environmental conditions as provided in Section 34 31 03 General Traction Power Requirements, unless otherwise indicated.
- B. Ratings
 1. The transformers shall have the following ratings:

KVA Rating:	Self-cooled, 75kVA
Primary Voltage:	27,500 volts, 1-phase, 2-wire, 60 Hz (operated with primary

	winding connected between one phase and ground) The transformers shall be capable of withstanding instantaneous overvoltages on the primary up to 29 kV.
Primary taps:	Nominal plus or minus 2 x 2.5% full capacity high voltage windings, no load, de-energized.
Basic Impulse Level on Primary	250kV
Secondary Voltage	240/120 Volts, 1-phase, 3-wire, 60 Hz
Basic Impulse Level on Secondary	30 kV
Total Losses	<2%
Efficiency	98.88% (min)
Impedance	3.2% plus or minus 7-1/2%

2. The transformer shall be of sealed-tank construction of sufficient strength to withstand a pressure of 7 psi without permanent distortion. The cover shall be welded and the fastenings tamper-resistant. The transformer shall remain effectively sealed for the ambient temperature range.
3. Coils shall be wound with copper conductors.
4. Core and coil assembly shall be a wound core type, using high grade, grain oriented silicon steel laminations carefully annealed after fabrication to restore high magnetic permeability. Magnetic flux shall be kept well below the saturation point.
5. Proto-type tests shall be conducted on transformers in accordance with the provisions of ANSI C57.12.90 and shall include, as a minimum, the following tests:
 - i. Ratio
 - ii. Polarity and phase relations
 - iii. No-Load Loss
 - iv. Full-Load Loss
 - v. Short Circuit
 - vi. Excitation Current
 - vii. Impedance Voltage
 - viii. Load Loss

- ix. Applied Potential
- x. Induced Potential
- xi. QA Impulse Test
- xii. The owner and/or its representatives shall have the option to witness these tests. The owner will require certified test reports from an approved third-party testing agency after the tests are performed and successfully completed.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. The transformers shall be shipped to the site oil-filled, along with a copy of factory certified test report for each transformer.
- B. Verify that equipment pads are ready to receive the transformers.
- C. Verify field measurements are as shown on the Contract Drawings.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install safety labels in accordance with the requirements of NEMA 260.

3.03 FIELD QUALITY CONTROL

- A. Test dielectric liquid to ASTM D1816, using 25,000 volts minimum breakdown voltage, after installation and before energization from system.
- B. Test transformer to ANSI/IEEE C57.12.90.
- C. Perform acceptance and commissioning tests in accordance with approved field test procedures.

3.04 TRANSFORMER TAP ADJUSTMENT

- A. Adjust the taps on the Primary Tap Changer so that the desired secondary voltage is obtained.

END OF SECTION

SECTION 34 31 31

MEDIUM VOLTAGE POLE MOUNTED FUSED DISCONNECTS

PART 1 – GENERAL

1.01 DESCRIPTION

- A. This Section covers the specification for the procurement, installation and testing of the Medium-Voltage Pole Mounted Fused Disconnects for the 27.5 kV (Single phase to ground), 60 Hz auxiliary power distribution system as described herein and shown on the Contract Drawings.
- B. The technical characteristics and size shall be in accordance with the limits specified on the Contract Drawings and with the parameters listed in this Section.

1.02 RELATED SECTIONS

- A. Section 34 31 03 - General Traction Power Requirements
- B. Section 34 31 86 - Feeder and Rail Return Cables
- C. Section 34 31 16 - TPF Grounding and Bonding
- D. Section 34 31 49 - Surge Arresters

1.03 SUBMITTALS

- A. Refer to Section 01 33 00, Submittal Procedures for review process.
- B. Fused Disconnect Assemblies
 - 1. Provide complete and detailed shop drawings of the integrated fused disconnect, with all ratings described, installation instructions, dimensions, and weights, as a complete assembly.
 - 2. Provide complete and detailed shop drawings for miscellaneous steel supports and clearances resulting to the OCS support structure.
- C. The following items shall be submitted for installation of the fused disconnects:
 - 1. Shop Drawings
 - 2. Product Data Sheets
 - 3. Manufacturer's Catalog Data
 - 4. Test Data
- D. Factory Test Reports

- E. Field Test Reports
- F. Manufacturer's Installation Instructions
- G. Manufacturer's Operation and Maintenance Manuals
- H. Manufacturer's Certificate

1.04 QUALITY ASSURANCE

- A. Conform to these specifications and to the applicable requirements of the latest edition of the following codes, regulations and standards:
 - 1. Institute of Electrical and Electronics Engineers (IEEE)
 - 2. American National Standards Institute, ANSI C2, ANSI C37.41, and Z55.1
 - 3. National Electrical Manufacturers Association, NEMA SG 5, NEMA SG 6, NEMA 260
 - 4. National Fire Protection Association, NFPA 70
 - 5. Underwriters Laboratories, UL 467
- B. Conform to all other applicable laws, ordinance and requirements of the local agencies and utility companies having jurisdiction.
- C. In the event of any conflicts in the provisions stipulated in the referenced codes, regulations or standards and the specifications, the most stringent provision, as determined by the Engineer, shall govern.

PART 2 – PRODUCTS

2.01 MATERIALS AND EQUIPMENT

- A. Equipment shall be suitable for continuous operation under the environmental conditions as provided in Section 34 31 03 General Traction Power Requirements, unless otherwise indicated.
- B. Power fuse assemblies Outdoor Pole Mounted Fused Disconnects
 - 1. Power fuse assemblies shall be of the vertical 180 degree opening style, similar to S&C type SMD-1A, as shown on the drawings.
 - 2. Power fuse assemblies shall consist of a mounting and a replaceable fuse unit. The mounting shall include a galvanized steel base, post insulators, upper and lower contact assemblies, and a fuse unit end fittings. Upper and lower contact assemblies shall include a rugged bronze alloy castings and silver clad contacts. Fuse unit end fittings shall include silver clad contact surfaces as well.
 - 3. Fuse unit shall consist of a fusible element, a spring driven arcing rod, and a solid material arc-extinguishing medium contained within a filament wound glass-epoxy tube.

4. The mountings shall be shipped assembled with porcelain post insulators. The fuse unit shall be shipped separately.

C. Accessories

1. Provide surge arresters (metal-oxide type) that are of distribution class on the load side of the Power Fuse assembly, where indicated on the Contract Drawings.
2. Provide pothead type terminations for primary cables at the pole where they connect to the power fuse assembly.
3. Provide compression connectors for terminating the primary cables on to the Power Fuse assembly. Provide conductor clamps on the line side for feeder taps.
4. Provide one (1) spare set of a fuse unit and end fittings with the fuse assemblies.

D. Fused Disconnects shall be manufactured by one of the following:

1. ABB – ASEA Brown Boveri
2. S&C Electric
3. PowerCon Corporation
4. Southern States
5. Or approved equal

E. The fused disconnects shall be used to provide auxiliary power to the TPFs. This auxiliary power shall be tapped from the single phase, 27.5 kV, 60 Hz traction power distribution system as shown on the design drawings. The fused disconnect ratings shall be as follows:

- | | | |
|----|---------------------------|---------------|
| 1. | Nominal Voltage | 27.5 kV |
| 2. | Maximum Design Voltage | 29.0 kV |
| 3. | System Voltage | 46.0 kV class |
| 4. | Basic Impulse Level | 250 kV |
| 5. | Power Frequency Withstand | 86 kV |
| 6. | Continuous Current | 200 Amps |
| 7. | Short Circuit Rating | 12,000 Amps |

PART 3 – EXECUTION

3.01 PREPARATION

- A. Transmit submittals and deliverables required by this Section.
 - 1. Ensure all components are in suitable condition to receive the work of this Section.

3.02 INSTALLATION

- A. Materials and equipment shall be applied, installed, and connected as recommended by the manufacturer.

3.03 INSPECTION AND TESTING

- A. All components of the Fused Disconnects shall be given the manufacturer's factory tests to ensure that all equipment adequately meets the applicable requirements of ANSI, IEEE, and NEMA Standards, and as specified herein.
- B. The units shall be tested for phase to ground short circuits. Tests sustaining these ratings shall be performed at the maximum voltage, with current applied for at least 10 cycles. Certified test abstracts shall be furnished to the Engineer for approval.
- C. All components of the Fused Disconnects shall be inspected and tested at the factory per manufacturer's recommendations.
- D. Perform field inspection and testing after installation.
- E. Visually inspect for physical damage.
- F. Check torque of bolted connections, including cable terminations, either by observing the bead of indicating compound to confirm that it is still intact, or with a torque wrench to confirm the joint is tightened to the manufacturer's specifications.
- G. Perform insulation resistance test on single phase wire to ground.

END OF SECTION

SECTION 34 31 32

AUTOMATIC AND MANUAL TRANSFER SWITCHES

PART 1 – GENERAL

1.01 DESCRIPTION

- A. This Section covers the requirements for outdoor pad-mounted Automatic Transfer Switches (ATS) and Manual Transfer Switches (MTS). The following equipment shall be furnished:
- B. ATS units shall be the exterior, pad-mounted type.
- C. MTS units shall be exterior type suitable for mounting on an Unistrut frame.

1.02 RELATED SECTIONS

- A. Section 34 31 29 TPF Auxiliary Power Systems

1.03 DOCUMENTS, REFERENCES, AND STANDARDS

- A. The ATS and MTS equipment shall be designed and implemented to the latest revision, at the time of award of contract, of the applicable codes and standards of the following organizations:
 - 1. American National Standards Institute (ANSI)
 - 2. International Organization for Standardization (ISO)
 - 3. National Electrical Manufacturers Association (NEMA)
- B. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. IEEE 446, IEEE Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Application
 - 2. IEEE 299, IEEE Standard Method for Measuring the Effectiveness of Electromagnetic Shielding Enclosures
 - 3. IEEE C57.12.28, IEEE Standard for Pad-Mounted Equipment – Enclosure Integrity
 - 4. IEEE 693, IEEE Recommended Practice for Seismic Design of Substations
- C. International Standards Organization (ISO):
 - 1. ISO 9001, Quality Management Systems – Requirements
- D. Underwriters Laboratories (UL):
 - 1. UL 50, Enclosures for Electrical Equipment

2. UL 1008, Standard for Transfer Switch Equipment
- E. National Electrical Manufacturers Association (NEMA):
 1. NEMA ICS 10, AC Automatic Transfer Switches
- F. National Fire Protection Association (NFPA):
 1. NFPA 70 National Electrical Code
 2. NFPA 110 Emergency and Standby Power Systems

1.04 SUBMITTALS

- A. Submittals shall be made including but not limited to the following:
 1. List of parts for all equipment required to complete the design specified herein.
 2. Product Data: Submit equipment and material lists, manufacturer's descriptive and technical literature, catalog cuts, seismic qualification, and product verification list with pictorial view and full performance specifications.
 3. Shop Drawings:
 - i. Clearly present sufficient information to determine compliance with drawings and specifications.
 - ii. Include electrical ratings (including withstand), dimensions, weights, mounting details, conduit entry provisions, side view, equipment and device arrangement, elementary and interconnection diagrams, factory relay settings, and accessories.
 - iii. Submit interconnection diagrams and site plans showing connections to primary and secondary sources of power, load, control and annunciation paths.
 - iv. Complete nameplate data, including manufacturer's name and catalog number.
 - v. A copy of the markings that are to appear on the transfer switches when installed.
 4. Factory and Field commissioning test procedure with pass/fail test criteria.
 5. Test Reports from the factory and field commissioning testing.

1.05 MANUALS

- A. When submitting the shop drawings, submit companion copies of complete maintenance and operating and maintenance manuals, including technical data sheets, wiring diagrams, and information for ordering replacement parts.

- B. Three weeks prior to delivery, submit four copies of a final updated maintenance and operating manual.
- C. Include complete diagrams that indicate all pieces of equipment and their interconnecting wiring.
 - 1. The wiring diagrams shall identify the terminals to facilitate installation, maintenance, operation, and testing.

1.06 PROJECT CONDITIONS

- A. Equipment shall be suitable for continuous operation under the environmental conditions as provided in Section 34 31 03 General Traction Power Requirements, unless otherwise indicated.

PART 2 – PRODUCTS

2.01 GENERAL REQUIRMENTS

- A. All equipment and products shall be new, non-refurbished, and free of defects, with the original manufacturer's warranty.

2.02 AUTOMATIC TRANSFER SWITCH

- A. Automatic transfer switches shall transfer electrical load from the primary power sources to the secondary power source when the primary source fails or is reduced more than 20 percent of its rated voltage. The transfer switch shall transfer the electrical load back to the primary utility power source when such source is restored.
- B. Configuration: Double pole – single throw
- C. Transfer switch shall be double-throw actuated by a single electrical operator momentarily energized and connected to the transfer mechanism. The switch shall be capable of transferring successfully in either direction at 80 percent of rated voltage.
- D. Normal and emergency contacts shall be positively interlocked mechanically and electrically to prevent simultaneously closing. Main contacts shall be mechanically locked in position in both primary and secondary positions without the use of hooks, latches, magnets, or springs and shall be silver tungsten alloy and protected by arcing contacts with magnetic blowouts on each pole.
- E. ATS shall be rated and configured for 240 VAC, 2 pole, 3 wire, 60 Hz. (2 phases, neutral, and ground).
- F. Provide 2 pole molded case circuit breakers as indicated on the Contract Drawings.
- G. Controls: ATS shall be provided with the following:
 - 1. Normal voltage fluctuation time delay to delay transfer, adjustable 0.5 to 6 seconds;

2. Transfer to emergency time delay adjustable 0 to 60 seconds;
 3. Retransfer to normal time delay, adjustable 0 to 15 minutes in one minute increments;
 4. Momentary test switch to simulate normal power failure;
 5. Manual reset switch to retransfer to normal power;
 6. Manual reset switch to bypass time delay on retransfer to normal power supply;
 7. White indicating light energized when automatic transfer switch has connected load to primary power source.
 8. Amber indicating light energized when automatic transfer switch has connected to secondary power source.
 9. Bypass/isolation switches for uninterrupted power to the load during switch maintenance and testing.
 10. A set of contact rated 10 amps, 250 Vac to enable future remote indication of transfer and retransfer, connection to normal and standby supply, and availability of normal and standby sources (voltage sensing), and system trouble.
 11. Factory installed space heater with thermostat.
- H. All contacts, control wiring and accessories shall be accessible from the front.
- I. The transfer switch, complete with all timers, relays, and accessories shall be in accordance with UL 1008.
- J. Assembly and Test: The switch shall be completely wired, assembled, and tested by the switch manufacturer.
- K. ATS enclosure shall be Type 4X and stainless steel. Provide a lockable, gasketed, hinged door that extends the full height of the enclosure.
- L. Enclosure shall be designed for mounting on a concrete pad. Minimum 4 inch sill shall be provided.
- M. Provide microprocessor-based indication unit with communication package, enabling ATS status, alarms and electrical load data to be transmitted to the TPF SCADA system.

2.03 MANUAL TRANSFER SWITCHES (MTS)

- A. Manual transfer switch shall consist of (2) two mechanically-interlocked molded case circuit breakers, cam-style male connectors, power distribution block and grounding terminals, all housed within a padlockable enclosure. The enclosure shall be suitable for connection of single phase 240 Vac, 2 pole, 3 wire (2 phases, neutral, and ground).
- B. MTS shall be StormSwitch as manufactured by ESL Power Systems, Inc. or equal.

- C. MTS enclosure shall be Type 4X and stainless steel. The main access shall be through an interlocked, lockable, gasketed, hinged door that extends the full height of the enclosure. Access for portable generator cables with female cam-style plugs shall be via cable entry openings in the bottom of enclosure. A hinged flap door shall be provided to cover the cable openings when cables are not connected; the hinged flap door shall allow cable entry only after the main access door has been opened.
- D. Cam-style male connectors (inlets) shall be UL Listed single-pole separable type and rated 400 amps at 600VAC. Cam-style male connectors shall be color coded. Cam-style male connectors shall be provided for each phase and for ground, and shall also be provided for neutral. Each of the phase cam-style male connectors within the enclosure shall be factory-wired to a molded case circuit breaker. The ground cam-style male connectors shall be bonded to the enclosure, and a ground lug shall be provided for connection of the facility ground conductor. The neutral cam-style male connectors shall be factory wired to a power distribution block. None of the cam-style male connectors shall be accessible unless both molded case circuit breakers are in the "OFF" position and the main access door is open.
- E. A power distribution block shall be provided for load-side field wiring. The power distribution block shall be factory wired to the molded case circuit breakers.
- F. Molded case circuit breakers shall be UL Listed and the short circuit interrupt rating shall be a minimum of 65 kAIC at 240 VAC. Trip rating of the molded case circuit breakers shall be as shown on the drawings. One molded case circuit breaker shall be fed from utility power; the other molded case circuit breaker shall be fed from the cam-style male connectors to supply power from a portable generator. Both molded case circuit breakers shall include UL Listed door-mounted operating mechanisms, preventing the opening of the main access door unless both breakers are in the "OFF" position. Both molded case circuit breakers shall be mounted behind a deadfront panel. The load-side of the molded case circuit breakers shall not be energizable unless the main access door is closed and one of the molded case circuit breakers is in the "ON" position. The (2) molded case circuit breakers shall be safety interlocked by mechanical means to ensure that only one breaker can be closed at any given time.
- G. MTS shall have a factory installed Heater/Thermostat/De-Humidistat.
- H. MTS shall provide status, alarms and electrical load data to be transmitted to the TPF SCADA system.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Each ATS Enclosure shall be installed on an external concrete pad in accordance with the Supplier's instruction.
- B. Install the MTS (with integral Tap Box) on the exterior of the building enclosure per the design and integrate with the substation auxiliary control power panel (ACPP).
- C. Connect the enclosure as indicated on the drawings. Exposed conduits shall be rigid steel.
- D. The concrete pad will be provided as follows:

1. The concrete pad shall be reinforced and at least 12 inches thick. It shall extend at least six inches beyond the equipment in all directions.
2. Provide compacted base aggregate below the pad. Provide conduit stub-ups as required.

3.02 TESTING

- A. Notify Caltrain not less than 10 Working Days in advance of each factory test and indicate the anticipated duration of the test.
 1. Factory Testing
 - i. Factory testing shall be completed according to manufacturer's procedures and accepted industry practices.
 2. Factory results to be submitted for record.
- B. Field Tests:
 1. Megger field wiring and record values on test report.
 2. Following completion of ATS installation and after making proper adjustments and settings, site tests shall be performed in accordance with manufacturer's written instructions to demonstrate that each ATS functions satisfactorily and as specified. Test reports shall describe adjustments and settings made and site tests performed. All measurements made shall have their value recorded in the test report to be provided to Caltrain.
 3. After energizing circuits, demonstrate the interlocking sequence and operational function for each ATS at least three times.
 - i. Simulate power failures of primary source to the ATS and of secondary source with normal source available.
 - ii. Verify time-delay settings.
 4. As left setting shall be provided to Caltrain for each site installed.

END OF SECTION

SECTION 34 31 33

TRACTION POWER TRANSFORMERS

PART 1 – GENERAL

1.01 SCOPE

- A. The work of this Section consists of designing, manufacturing, furnishing, factory testing, delivering, installing, and field testing 60 MVA, 115 kV primary voltage, 2 x 27.5 kV secondary rated voltage, oil immersed, ONAN type (including provisions for ONAF), 60 Hz, heavy duty outdoor Traction Power Transformers, with high voltage automatic load tap changer (LTC) on the primary side.
- B. The Traction Power Transformers for a substation shall be identical if two are required.

1.02 REFERENCE STANDARDS

- A. American National Standards Institute (ANSI – Some of the C Series of Standards listed herein are also IEEE Standards):
 - 1. B.1.1 Unified Inch Screw Threads (UN and UNR Thread forms)
 - 2. B1.13M Screw Thread Gauging Systems for Dimensional Acceptability # Inch and Metric Screw Threads
 - 3. C2 National Electrical Safety Code
 - 4. C29.1 Electrical Power Insulators – Test Methods
 - 5. C29.7 Wet Process-Porcelain Insulators-High-Voltage Line – Post Type, including Supplement C29.7a
 - 6. C29.9 Wet-Process Porcelain Insulators (Apparatus, Post Type)
 - 7. C37.2 Electric Power System Device Function Numbers and Contact Designations
 - 8. C37.90 Relays and Relay Systems Associated with Electric Power Apparatus
 - 9. C39.1 Requirements for Electrical Analog Indicating Instruments
 - 10. C57.12.00 Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
 - 11. C57.12.10 American National Standards for Transformers – 230 kV and Below 833/958 through 8,333/10,417 kVA, Single-Phase, and 750/862 through 60,000/80,000/100,000 kVA Three-Phase, without Load

- Tap Changing; and 2,750/4,687 Through
60,000/80,000/1000,000 kVA with Load Tap Changing
– Safety Requirements
12. C57.12.28 Standard for Pad-Mounted Equipment – Enclosure Integrity
 13. C57.12.70 Terminal Markings and Connections for Distribution and Power Transformers
 14. C57.12.80 Standard Terminology for Power and Distribution Transformers
 15. C57.12.90 Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers and Guide for Short-Circuit Testing of Distribution and Power Transformers
 16. C57.13.5 Trial-Use Standards of Performance and Test Requirements for Instruments and Transformers of a Nominal System Voltage of 115 kV and Above
 17. C57.19.00 General Requirements and Test Procedures for Power Apparatus Bushings
 18. C57.91 Guide for Loading Mineral Oil Immersed Transformers (Including Corrigendum 1)
 19. C57.93 Guide for Installation of Liquid Immersed Power Transformers
 20. C57.98 Guide for Transformer Impulse Tests
 21. C57.100 Standard Test Procedures for Thermal Evaluation of Liquid-Immersed Distribution and Power Transformers
 22. C57.106 Guide for Acceptance and Maintenance of Insulating Oil in Equipment
 23. C57.119 Recommended Practice for Performing Temperature Rise Tests on Oil- Immersed Power Transformers at Loads beyond Nameplate Ratings
 24. C57.123 Guide for Transformer Loss Measurements
 25. C57.131 Standard Requirements for Load Tap Changers
 26. C57.136 Guide for Sound Level Abatement and Determination for Liquid Immersed Power Transformers and Shunt Reactors
 27. C62.11 IEEE Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits

28. C84.1 Voltage Ratings for Electrical Power Systems and Equipment (60 Hz)
- B. American Society for Testing and Materials (ASTM):
1. D117 Standard Guide for Sampling, Test Methods, Specifications and Guide for Electrical Insulating Oils of Petroleum Origin
 2. D1816 Test Method for Dielectric Breakdown Voltage of Insulating Oil of Petroleum Origin Using VDE Electrodes
 3. D3487 Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus
 4. D1275B Corrosive Sulfur Guidelines
- C. Institute of Electrical and Electronics Engineers (IEEE):
1. 48 Standard Test Procedures and Requirements for 2.5 kV through 765 kV Alternating-Current Cable Terminations
 2. 62 Guide for Diagnostic Field Testing of Electric Power Apparatus – Part 1: Oil Filled Power Transformers, Regulators, and Reactors
 3. 519 IEEE Recommended Practices and Requirements for Harmonic Control in Electric Power Systems
 4. 693 Recommended Practices for Seismic Design of Substations
 5. 980 Guide for Containment and Control of Oil Spills in Substations
 6. C57.13 IEEE Standard Requirements for Instrument Transformers
- D. National Electrical Manufacturers' Association (NEMA):
1. BU 1 Busways
 2. EI 21.2 Instrument Transformers for Revenue Metering (125 kV BIL through 350 kV BIL)
 3. ICS 4 Industrial Control and Systems: Terminal Blocks
 4. ICS 6 Industrial Control and Systems: Enclosures
 5. LA 1 Surge Arresters
 6. WC 70 Nonshielded 0-2 kV Cables (ICEA S-95-658)

- 7. TR1 Transformers, Regulators, and Reactors
- E. National Fire Protection Association (NFPA):
 - 1. 70 National Electrical Code (NEC)
- F. International Electrotechnical Commission (IEC):
 - 1. 60076 Power Transformers
 - 2. 296 Insulating Oil (for HV Transformer)
 - 3. 60214 On-load Tap Changer (LTC)
 - 4. 60137 Bushings
 - 5. 60099-4 Surge Arresters
- G. European Standard (EN):
 - 1. EN 50329:2003+A1:2010 Railway applications. Fixed installations. Traction transformers
- H. American Railway Engineering and Maintenance-of-Way Association (AREMA):
 - 1. Chapter 33, Part 6 Power Supply and Distribution Requirements for Railroad Electrification Systems

1.03 RELATED SECTIONS

- A. 34 31 03 - General Traction Power Requirements
- B. 34 31 76 - TPF Testing and Commissioning
- C. 34 31 13 - Basic Traction Power Materials and Methods
- D. 34 31 16 - TPF Grounding and Bonding
- E. 03 11 00 - Concrete Forming
- F. 03 15 00 - Concrete Accessories
- G. 03 20 00 - Concrete Reinforcing
- H. 03 30 00 - Cast-in-Place Concrete
- I. 03 35 00 - Concrete Finishing
- J. 05 12 00 - Structural Steel Framing
- K. 05 50 00 - Metal Fabrications
- L. 09 90 00 - Painting and Coating

1.04 SERVICE CONDITIONS

The transformers shall be suitable for operation at rated MVA under the following conditions:

- A. Ambient Temperature Ranges:

Minimum Temperature: -10°C (15°F)

Maximum Daily Temperature: +42°C (108°F)
- B. Current and Voltage Distortion: The manufacturer shall consider the specific harmonic content of the traction load in the design and testing of the traction power transformers.

1.05 BASIS OF TRANSFORMER SIZING

- A. The power transformer shall have a continuous rating of 60 MVA within the specified temperature-rise limitations and within the limitations of the established standards. The purchaser will provide daily load cycle curves which will not exceed a RMS loading of 60 MVA. The Manufacturer shall verify by calculation that the transformers are adequate for the load cycle indicated.
- B. The transformers will be subject to severe working conditions arising from repetitive short circuits on the overhead contact system. These frequent short circuits may vary in amplitude and duration. The manufacturer shall consider at least one daily short circuit without exceeding the normal loss of life expectancy. The transformers will be subject to balanced short circuits (catenary-to-autotransformer feeder) but most frequently to unbalanced short circuits (catenary-to-ground and autotransformer feeder-to-ground). Consequently, transformer cores shall be of augmented mechanical strength and shall include a strengthened internal bracing system for all windings. The transformers shall be carefully designed and built to withstand the inherent severe mechanical and thermal stresses generated due to these repetitive fault conditions. The manufacturer shall provide thermal analysis calculations in accordance with Paragraph 1.5.D.
- C. The transformers will be subject to the widely varying load magnitudes inherent to traction power systems, resulting in pulsating forces. These forces shall not impair transformer performance and shall not cause the transformers to exceed the normal loss of life.
- D. The manufacturer shall be responsible for performing an engineering design study that includes the following:
 - 1. Hottest spot conductor, top oil and average winding temperature profiles (over 24 hours) shall be provided on the basis of daily load profiles in Appendix B. (appendix will be provided at a later date.) Temperature rises shall not exceed the limits specified in Paragraph 2.2.A.7. A detailed thermal analysis shall be submitted for approval to verify that winding hottest spot temperature and normal loss of life are not exceeded.

2. The automatic load tap changers (LTC) and the transformer equipment shall be able to withstand these current profiles on any tap position of the LTC. Design shall consider the LTC position yielding the highest temperature rise. The load tap changer shall be able to switch the maximum current indicated on the load profiles. The LTC rated through current shall be selected accordingly.
 3. All transformers shall be ONAN rated. However, provision shall be made for possible future installation of fans, wiring, controls and control cabinet for ONAF rating.
 4. On the basis of the continuous MVA rating, the manufacturers shall perform a thermal analysis reflecting the overload capability specified in Paragraph 2.2.A.3. LTC and other equipment shall withstand this overload criterion. Winding and oil temperatures (average and hot spot) shall not exceed the limits specified. Calculations shall be submitted for review and acceptance by Caltrain. A temperature rise design test shall be performed on the first transformer unit. Test results shall be compared to the calculation results.
 5. The manufacturer shall provide detailed loading capabilities of the transformer for various ambient temperatures and load cycles.
- E. Temperature References and Daily Load Profiles: The oil flash point shall not be less than 145 degrees C. The manufacturer shall provide the oil critical flash point and other pertinent oil characteristics.
- F. Temperature References Continuous MVA Ratings: The continuous rated power shall be referenced to an average ambient temperature of +40 degrees C and an average winding temperature rise not exceeding 55 degrees C. For this given condition, the winding continuous hottest spot temperature rise over ambient shall not exceed +80 degrees C.
- G. Temperature References and Temperature Rise Design Test: The average winding temperature rise shall not exceed 55 degrees C at continuous rated power at an ambient temperature of 40 degrees C. In addition, the transformers shall withstand an immediate increase to 150% percent of rated MVA for 1 hour with an average winding temperature rise not to exceed 75 degrees C. During this loading cycle, the maximum winding hottest-spot temperature rise over ambient shall not exceed 80 degrees C by resistance.
- The Manufacturer may propose an alternative temperature rise design test utilizing the equivalent RMS loading for the load cycle indicated in this paragraph. If an alternative is proposed, manufacturer shall submit the cost deduct and the specifics of the alternative test with the quotation.
- H. The manufacturer shall certify that the transformer complies with the above engineering requirements.
- I. Purchaser requires a model of the transformer as a function of frequency based either on engineering calculations or SFRA open and short circuit measurements. The model shall be suitable for use in the Electromagnetic Transients Program or equivalent. The purpose of this model is to include the

effects of transformer impedance variation with frequency for train generated harmonics in the audio frequency range. These harmonics may have an impact on the utility network as well as track circuit equipment.

Bidders shall state how the model is proposed to be developed and when this model will be provided to the purchaser.

1.06 DESIGN LIFE

The traction power transformer shall have a design life not less than 40 years. The manufacturer shall provide sufficient data in this regard to the satisfaction of Caltrain.

1.07 SUBMITTALS

A. In addition to the submittals specified in Section 34 31 03, provide design calculated values, shop drawings and data that include the following:

1. Transformer winding resistance.
2. Transformer impedance.
3. Transformer test plan and detailed procedure including design and routine tests.
4. Nameplate data.
5. Hydraulic diagram including location of valves and joints.
6. Transport and delivery plan.
7. Transformer foundations.
8. Transformer oil containment arrangements.
9. Calculation of transformer insulation life.
10. Seismic qualifications report.
11. Bill of Materials (with manufacturer and manufacturers' model numbers in Microsoft Excel spreadsheet format.)
12. Product data and performance characteristics of On-Load Tap Changers (OTC)
13. Other product data including current transformers, surge arresters, protective devices and instruments, and other appurtenances as required in the specification.

B. Provide the following information with the quotation:

1. Transformer weight.
2. Transformer outline dimensions with and without radiators.

3. Cooling oil capacity in gallons.
4. Any deviations from the specification.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

- A. Power transformers shall be manufactured by any of the following:
 1. ABB Electric.
 2. Or equal.

2.02 RATINGS AND CONNECTIONS

- A. Each transformer shall be single-phase, oil-immersed outdoor type for operation on a 60 Hz system with the following ratings and connections:

1. Voltage and Frequency:
 - a. Rated Primary Voltage 115 kV
 - b. Nominal Secondary Voltage 2 x 25 kV
 - c. No-load Secondary Voltage
Assuming 115 kV Primary
Voltage and a Neutral Tap 55.0 kV (2 x 27.5 kV)
 - d. Frequency 60 Hz
2. Windings and Phase Connection:
 - a. Primary Winding Single Phase
 - b. Connection 115 kV Phase to phase (H1 to H2)
 - c. Secondary Winding Single phase.

Secondary Winding may be constructed as either one winding with its central point brought out and grounded; or it may comprise two separate windings such that the voltages in them are in counter-phase (180 degrees apart).

- d. Connection:

1st Terminal (X1)	27.5 kV Nameplate Voltage Catenary to Ground (X0 bushing)
2nd Terminal (X2)	27.5 kV Nameplate Voltage Autotransformer Feeder to Ground (X0 bushing)

If the first alternative option of secondary winding as described above is used, the center tap shall be solidly connected to ground and rails.

3. Rated Power:
 - a. Nominal ONAN Rating

55 degrees C	Rise at 40
Degrees C ambient	60 MVA
 - b. One-Hour Rating 90 MVA
 - c. ½ Secondary Winding 30 MVA
 - d. Full Capacity Taps Yes

4. Rated Impedance (Nominal Tap):
 - a. 10 percent on 60 MVA basis.

Maximum Tolerance value	± 7.5 percent of specified value
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5. Losses and Noise:
 - a. No Load Losses, kW
(at 85 degrees C) ≤ 35

Maximum Tolerance	Not to exceed the specified value by more than 10 percent
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 - b. Full Load Losses, kW
(at 85 degrees C) ≤ 115

Maximum Tolerance	Not to exceed the specified value by more than 6 percent
-------------------	--
 - c. Average Noise Level, dBA
(measurement according to NEMA TR1) 78

6. System Voltage and Insulation:
 - a. Nominal Voltage 115 kV
 - b. Maximum System HV 121 kV
 - c. Operating Voltage LV 27.5 kV
 - d. Normal Minimum HV 109 kV

- e. Emergency Minimum HV 104 kV
 - f. Basic Insulation Level:
 - HV Winding 550 kV
 - LV Winding 250 kV (L-G)
 - LV Ground/Center Tap Insulation Level 15 kV
7. Overload Ratings Without Additional Loss of Life:
- a. Maximum Continuous Average Winding Temp. Rise over 40 degrees C Ambient, at Rated Power 55 degrees C
 - b. Followed by 150% of rated MVA for 1 hour with an average winding temperature rise not to exceed 75 degrees C
 - c. Winding Maximum Hottest Spot Temperature Rise over 40 degrees C Ambient, at Rated Power 80 degrees C
8. Tap Changer:
- a. Automatic Load Tap Changer (LTC):
 - Type: Single phase
 - REINHAUSEN type with vacuum interrupters or equal. The voltage shall be adjusted symmetrically and simultaneously in both the catenary and the autotransformer feeder polarities.
 - Tap Changer Location: Primary side
 - Range: +10% through -8% at 1.1% step, OLTC Full Capacity Below Nominal;
 - Step: 1.10 percent
 - Number of Tap
 - Positions: 19
 - Nominal Tap: 16, Corresponding to 115kV
 - Tap Selector Operating Time (Step to step): 6 seconds max.
 - Diverter Switch Not more than

Operating Time:	60 milliseconds
Parallel Operation:	No Automatic Remote
Voltage Regulation:	Yes
Minimum Guaranteed Number of Operation (At full load) before major maintenance:	500,000
Insulating Medium	Mineral Oil

Automatic Voltage Regulator (AVR) used to control the voltage regulation of the LTC shall feature remote communication capability, and shall be connected to the SCADA system.

The AVR shall monitor the direction of the current through the transformer and periods of regeneration (energy flowing towards the utility grid) shall be excluded from the voltage control logic.

The LTC shall monitor and control the voltage on the secondary side of the HV transformer. Control parameters, such as the voltage set point, dead band, and reaction time shall be user-adjustable. LTC reaction time shall have an initial setting of 2 minutes. LTC operation shall be blocked when transformer load exceeds 100 percent of rated load.

Provisions shall be made for manual change of the LTC, both through local manual and via remote control.

LTC status and secondary voltage shall be communicated via SCADA to the central control facility.

Warranty Requirement 5-year parts and labor warranty required on tap changers.

9. High-Voltage Side Terminal Arrangements:

- a. Type Bushings, top mounted
- b. Terminals Suitable for outdoor bus connections (see Contract Drawings)
- c. Quantity 2
- d. Max. Voltage Rating 121 kV
- e. BIL 550 kV

- f. Creepage Distance 101 inches (2565 mm)
10. Low-Voltage Side Terminal Arrangements:
- a. Type Bushings, top mounted
 - b. Terminals Suitable for overhead connection
 - c. Quantity 3
 - d. Max. Voltage Rating:
 - Power Bushings (2) 69 kV
 - Power Bushings
 - BIL(L-G) 350 kV
 - Neutral Bushing (1) 15 kV
 - Neutral Bushing BIL 110 kV
 - e. Minimum Clearance Distance Between LV Winding Bushings 25 inches (635 mm)
 - f. Min. Creepage Distance, Power Bushings 41 inches (1041 mm)
11. Winding Insulation Levels:
- a. Low Frequency Withstand Voltage:
 - 115 kV Terminals 230 kV
 - 2 x 27.5 kV Terminals (L-G) 95 kV
 - Secondary Winding Center Tap 34 kV
 - b. Full Wave Impulse Crest Voltage:
 - 115 kV 550 kV
 - 2 x 27.5 kV Terminals 250 kV
 - Secondary Winding Center Tap 110 kV
 - c. Chopped Wave Crest

Voltage: 115 kV	605 kV
2 x 27.5 kV Terminals	275 kV
Secondary Winding Center Tap	120 kV

12. Accessories (per transformer):
- a. Metal Oxide Surge Arresters (Station Class)
HV Side: 2
LV Side: 2
 - b. Mechanical Pressure Relief Device (Main Tank) 1
 - c. Safety Valve (Load Tap Changer) 1
 - d. Sudden Pressure Relay (Main Tank) 1
 - e. Gas Detector Relay 1
 - f. Winding Over Temperature 1
 - g. Liquid Thermometer with Switch 1
 - h. Oil Level Indicator (Main Tank) 1
 - i. Tap Changer Position Indicator 1
 - j. Tap Changer Position Transducer (4-20mA) 2
 - k. LTC Operation Counter 1
 - l. Control Cabinet 1
 - m. Control Cabinet-Load Tap Changer 1
 - n. Conservator (Main Tank) 1
 - o. Air Dryer (Main Tank) 1
 - p. LTC Conservator (Second Chamber) 1
 - q. LTC Oil Level Indicator 1

r.	LTC Sudden Pressure Relay	1
s.	LTC Safety Valve	1

2.03 WINDING DESIGN

- A. The winding design shall be such that any increase in volts per turn, resulting from operation of the tap changer and/or from utility voltage rise, does not result in core saturation. Transformers shall be designed to withstand +10 percent of the rated tap voltage on any tap position without significant increase of iron losses, noise level, or overheating of the laminations at full rated load. The manufacturer shall provide the nominal flux density in Tesla at nominal 60 Hz primary voltage, nominal tap for the proposed core steel type.
1. On any tap position of the load tap changer, transformer impedances shall not exceed the ohmic values after consideration of tolerances of ± 6 percent.
 2. Maximum flux density (induction) shall not be exceeded on any tap position, given the +10% in volts per turn. The manufacturer shall provide the maximum allowable induction value.
 3. The primary winding shall be designed to distribute, as far as possible, the voltage under surge conditions. The manufacturer shall describe its proposed technique for accomplishing this.
 4. The winding shall be capable of withstanding all impulse and dielectric tests specified in these specifications.
 5. Axial and/or radial insulating spacers at frequent intervals shall be permanently secured in place for cooling of windings. Spacers shall be arranged to assure positive and effective oil circulation all throughout the intended design life of the transformer. All insulating spacers shall be compressed at high pressure before installation in the windings.
 6. Suitable cooling liquid passages shall be provided in windings/core to limit the hottest- spot temperature rise.

2.04 SHORT CIRCUIT WITHSTAND CAPABILITY

The power transformers shall be designed and constructed to withstand the repetitive mechanical and thermal stresses as specified in Paragraphs 1.4 and 1.5, including the impact of a multi-shot autoreclosing scheme. The manufacturer shall submit certified short circuit test results for an equivalent traction power transformer, if available. If the type test certificate is judged inappropriate by Caltrain, a short circuit type test shall be performed on the first unit by an independent test laboratory. Test procedure shall be agreed upon between Caltrain and the manufacturer. Detailed test procedure shall be provided for approval by Caltrain. Transformer shall be designed such that one short circuit will occur per day will not cause an increased loss of life expectancy.

2.05 TAP CHANGERS

Each transformer shall be equipped with an automatic load tap changer (LTC) on the

primary winding as described in Paragraph 2.2.A.8. The LTC shall be composed of a selector and a diverter switch installed in an independent oil chamber from the main tank.

2.06 GROUNDING

The traction power transformer tank and all associated metallic equipment shall be permanently grounded with a minimum of 2 ground pads in compliance with the substation grounding system.

2.07 OIL CONTAINMENT

- A. Transformer oil containment structure shall have open area covered with non-skid galvanized steel grating on all sides of the transformer concrete pad as shown in the Contract Drawings.
- B. At one corner of this structure a sump shall be provided as shown on the Contract Drawings. All four sides shall slope 1 percent minimum towards the sump.
- C. Interior surface of the containment basin shall be painted with epoxy primer and polyurethane finish coat.
- D. Waterstops shall be provided at the construction joints as shown in the Contract Drawings.
- E. Structural steel beams shall support the galvanized steel grating.

2.08 CONSTRUCTION DETAILS

- A. Tank and Base:
 - 1. The transformer tanks shall be of welded steel construction. The cover will be bolted together with the tank walls through a special flange with stainless steel screws and nuts.
 - 2. The transformer tanks shall be suitable for filling with oil under full vacuum. The proposal shall include recommendations for back-pressure during filling.
 - 3. The transformer bases shall be chamfered to permit skidding or rolling in a direction parallel to the center line, and the chamfer shall have a slope ratio of 1:4 so that rollers may be easily started. Unchamfered bases against embedded steel channels may be used as an alternate.
 - 4. Pulling eyes shall be provided for pulling in four directions. The center of the eye shall be located not less than 8 inches (203 mm) above the base to permit the pulling shackles to clear the rollers on which the transformer is moved.
 - 5. All enclosures shall be weatherproof and designed to prevent the accumulation freeze of standing water along panel doors. Gaskets of doors shall be recessed and provided with mechanical gasket stops, or

shielded for adequate protection from the weather.

6. Oil-filling connections shall be provided with deflection plates inside the tank to prevent the force of incoming oil from impinging on the core and windings.
7. Transformers shall be provided with lifting lugs and jacking pads on four corners. Pads shall be located at least 22 inches (559 mm) above the base of the equipment. The jacking pad surface shall be at least 6 inches by 6 inches (152 mm by 152 mm). The center of the jacking pad surface shall have at least 10 inches (254 mm) free clearance from the side of the tank and base. The areas near the jack pads or surface shall be kept clear of all radiators, fans, boxes, piping, etc., to facilitate handling of jacks.
8. Lifting eyes shall be provided for the tank cover.
9. The centerlines of tank or base shall be permanently marked near the base on all 4 sides of the tank or case and shall be indicated on the shop drawings.
10. The shipping center-of-gravity shall be permanently and plainly marked "Shipping Center of Gravity" on 4 sides of the tank and base to aid in handling and shall be dimensioned on the shop drawing.
11. The gasketed surfaces around openings in the transformer tank and cover for such items as bushings, manholes, relief devices, etc., shall be raised sufficiently to prevent the accumulation of water around the gasket. All gaskets in contact with oil-bearing surfaces shall be of nitrile rubber or equal. Cork or corprene gaskets will not be acceptable.
12. Grounding Pads: Provide 2 NEMA drilled welded-on ground pads for grounding the tank, diametrically located at the corners.
13. The design shall permit oil samples to be taken from the main tank while the transformer is energized.
14. The design shall include a sight glass to allow the oil level in the tank to be checked.

B. Bushings:

1. The bushing arrangement and terminal designation shall be standard. The bushings shall be furnished with 4-hole NEMA pad terminals with cable/bus connectors.
2. All high-voltage bushings shall be oil-filled with a capacitance tap outlet.
3. For low voltage bushing configuration, see Paragraph 2.2.A.10.
4. Provide bushings with bushing-type current transformers.

C. Current Transformers:

1. Equip each bushing with multi-tap current transformers in compliance with IEEE Std C57.13, as follows:
 - a. 115 kV Winding (High Voltage)
 - i. Type: Bushing
 - ii. Quantity: 2 on each bushing
 - iii. Ratio: 600/5 multi ratio
 - iv. Accuracy Class: C400 with appropriate burden
 - b. 27.5 kV Winding (Low Voltage)
 - i. Type: Bushing
 - ii. Quantity: 2
 - iii. Ratio: 1200/5 multi ratio
 - iv. Accuracy Class: C400 with appropriate burden
 - c. Center Tap (Grounding)
 - i. Type: Bushing
 - ii. Quantity: 1
 - iii. Ratio: 1200/5 multi ratio
 - iv. Accuracy Class: C400 with appropriate burden

D. Surge Arresters: Surge arresters shall be single-phase, intermediate station class metal oxide type, pressure class 1, pedestal mounted, furnished complete with mounting and ground hardware, fabricated and factory tested in accordance with ANSI C62.11. Surge arrester protective characteristics shall coordinate with transformer insulation to give satisfactory protection to the traction power transformer per IEEE C62.11, IEEE 1313.2 and NEMA LA1. Surge arresters and surge counters shall be provided with NEMA standard connectors for securing copper or aluminum line conductors or bus. Surge arresters shall be appropriately insulated from the traction power transformer tank and shall be colored ANSI light gray. Surge arresters shall have additional threaded studs attached to XFMR enclosure and vinyl coated steel cable clamps to route and support ground conductors.

Surge Arrester ratings shall be as shown in the table below:

Service	115 kV	
	Power Transformer	
	Primary Side	Secondary Side
Rated Frequency, Hz	60	60

System Maximum Voltage, kV	121	29 (L-G)
Rated Voltage, kV	96	45
Maximum Continuous Operating Voltage (MCOV), Line to Ground, kV	76	36.5
Pressure Relief Device, kA, rms	60	60

- E. Connections: All bushings shall be mounted on the tank top or side, cable box configuration as shown on the Contract Drawings, and shall have silver-plated studs. The terminal arrangement shall be suitable for connections as shown on the Contract Drawings.

- F. Core and Coils:
 - 1. The core of each transformer shall be fabricated from the manufacturer's standard steel, grain oriented and laminations. The core shall be carefully assembled and rigidly clamped to insure adequate mechanical strength and minimum vibration under all operating conditions.

 - 2. The windings shall be of copper and have insulation of high dielectric and mechanical strength and shall be arranged to permit free circulation of oil. Proper internal barriers shall be provided. Additional insulation shall be provided on end coils to protect against line disturbances. The coils shall be made up, shaped and braced to provide for expansion and contraction due to temperature changes and to avoid abrasion of insulation. The coils shall be braced to prevent distortion due to any abnormal operating conditions.

 - 3. The core ground bushing connection shall be on the transformer tank top to facilitate testing of the core clamp insulation without opening the transformer tank. The bushing shall be connected by a removable ground strap to a ground pad on the tank top. The entire assembly shall be covered by a removable metal box. If the core ground bushing is not located within 508 mm (20 inches) of a manhole on the tank top, access shall be provided by a 242 mm (9.5 inches) handhole not further than 432 mm (17 inches) from the bushing. Bushing shall be Porcelain Products style number 20098, stud size 0.5-13NC-2, or approved equal.

- G. Transformer Insulating Oil: The transformer manufacturer shall supply insulating oil in 55- gallon drums or other suitable containers for filling the tanks at the substations after the transformers are installed. If oil is supplied by tanker trucks, any delays in filling shall be at the manufacturer's expense. The transformers shall be filled with dry inert gas for shipment, and delivered to the designated storage area. Ensure oil fill lines are contaminant free prior to filling. The manufacturer shall submit the following items to ensure that the correct insulating oil is supplied and the transformer tanks are filled as recommended:
 - 1. Manufacturer's standard specifications for the transformer insulating oil, including requirements that the oil be free of polychlorinated biphenyls

(PCB) and tested in accordance with ASTM D1816.

2. Instructions for oil storage, handling, and filling of the transformer tanks, including required quantities and procedures for filling at time of installation.
 3. Inspection services as required to verify that the type of oil supplied, and the handling and filling procedures following installation at the substation sites, are in accordance with the manufacturer's recommendations.
 4. Additional copies of the manufacturer's standard specifications for the transformer insulating oil, and instructions for the handling of oil and filling of tanks, shall be included in the manufacturer's Instruction Manual specified in this Section.
 5. Verify oil fill lines are containment free prior to filling with oil.
- H. Oil Preservation Equipment: The oil preservation system shall be an inert-gas pressure system or a conservator system in which oil is not in direct contact with the atmosphere. For the inert- gas protective system, the following provisions shall apply:
1. The transformer shall be provided with positive pressure, automatic, inert-gas protection in the form of a cushion of nitrogen gas above the oil in the main tank and any auxiliary oil-filled tanks.
 2. The gas control cabinet, which also shall house the nitrogen gas cylinder, shall be a separate weatherproof cabinet mounted vertically. The bottom of the cabinet shall be approximately 305 mm (one foot) from the transformer base pad.
 3. The gas system shall include purging and test valves, so arranged that a Fyrite Oxygen Analyzer, or approved equal, may be conveniently attached. The transformer tank supplied by the gas system shall have an outlet connection remotely located from the inlet connections to facilitate purging.
 4. The gas pressure in the transformer tank shall be maintained at a positive value at all times. Three NO alarm contacts suitable for 125 VDC shall be provided for signaling low and high transformer gas pressure and low cylinder pressure.
 5. One USA standard bottle of nitrogen gas shall be furnished with each transformer, pressurized at the working pressure and complete with gauge.
- I. Cooling Equipment:
1. Each transformer shall be equipped with sufficient number of radiators to operate as a self-cooled unit in accordance with the specified ratings. Provisions shall be made for installation of fans for future ONAN/ONAF operation. The manufacturer shall indicate the ONAF rating.

2. The transformers shall be provided with radiators attached to the tank by bolted and gasketed flanges. Radiators of the same nominal dimensions shall be interchangeable. A lifting eye shall be provided on each radiator. Provisions shall be made to permit removal of the radiator without interfering with the operation of the transformer. An oil tight blank flange shall be provided for each connection for use when the radiators are detached. A drain plug and vent plug shall be provided in each radiator header.
 3. The cooling fan support shall be provided on the transformers in manner which will permit easy removal of the fans for maintenance.
- J. Provisions for Cooling System Controls:
1. Provisions shall be made for a complete temperature-controlled cooling system.
 2. The manufacturer shall provide room for wiring route, control, and control cabinet.
- K. Control, Auxiliary Power, Instrument, and Alarm Wiring:
1. All control, auxiliary power and alarm circuits shall be completely wired to the control cabinets. All wiring shall run in separate, galvanized rigid steel or sealtite UV resistant conduits. Wiring terminations shall be on molded-type terminal blocks with compression-type terminals and laminated dust covers suitable for engraving. Terminal blocks shall be the molded type. Terminal blocks shall have at least 20 percent spare positions. Gages may be connected to the conduit system with short lengths of insulated flexible cable. Dust covers and terminal blocks shall be included.
 2. Terminations shall be segregated and separated as to low-voltage power, low-voltage control and metering, and low-level signal circuits. Not more than 2 wires shall be connected to one terminal. All terminal blocks for interface connections between the external wiring and the equipment wiring shall be enclosed and located in areas with adequate space and clearances. These areas shall allow convenient placement and termination of the external cables in neat and orderly arrays. Future cable removal or additions shall not require temporary removal or disconnection of adjacent unrelated cables. The location and arrangement of terminal blocks for all external wiring shall be subject to review and approval by Caltrain.
 3. Control and indication wiring shall be not smaller than No. 14 AWG. All control, instrument and alarm circuits shall be shielded. Control wire shall be stranded copper conductor, Type XHHW, with 600 V insulation. All wiring shall be capable of passing the Flame Resistant Test, NEMA WC 70, Section 6.12b.
 4. Wiring across hinges shall employ the use of No. 14 AWG, 41, strand, extra-flexible copper conductors. Hinge wiring shall be arranged so that any twisting shall take place in the longitudinal axis of the conductor,

rather than across the conductor.

5. The control cabinet shall be NEMA Type 4X with doors located on either side of the transformer tank and within reach of person standing at the transformer base level. It shall contain all auxiliary devices except those which must be located directly on each transformer. Doors shall be hinged and provided with stops to hold the doors in open position until released by the operator. Auxiliary panels shall be hinged or otherwise designed for ready access to relays, control devices and associated terminals for testing, adjustment and maintenance.
 6. Wiring and components shall be arranged so that instruments or devices may be removed and serviced without disturbing the wiring. No wire shall be routed across the face or rear of an instrument, junction box or other device in a manner which will prevent the opening of covers or obstruct access to leads, terminals, devices or instruments.
 7. The Cabinets shall be provided with internal illumination, a 120 VAC, 20 A outlet supplied from the 120 V control circuit, and strip heaters. Outlet shall be GFI type.
 8. All exposed wiring in the control cabinets shall be formed with wiring neatly grouped in bundles, using wiring cleats, or ties, and with groups substantially supported.
 9. The insulation or jacket of each insulated conductor in all multiconductor cables shall be color-coded for identification. Color coding shall be by actual color impregnation, not by printed wording or numbering.
 10. Only ring tongue, compression-type connectors which firmly grip the conductors shall be used. The crimping tools used shall be approved by the terminal manufacturer. Soldered terminal block or connection will be acceptable. The manufacturer's standard terminal block or connection will be supplied.
 11. Locknuts or lockwashers shall be applied to all stud type terminals. For screw-type terminals, a split type lockwasher shall be used between the terminal lug and screw head. The manufacturer's standard terminal block or connection will be supplied.
 12. Metal raceway shall be provided for all instruments requiring thermocouple connections in accordance with manufacturer's standard practices.
 13. Splices or parallel connections shall not be made in the transformer tank braces or in other non-accessible locations. Such connections shall be made at terminal blocks or readily accessible splice boxes.
- L. Control and Alarm Voltages:
1. All annunciator and protection circuits shall conform to ANSI standards.

2. The LTC auxiliary power supply, including LTC motor supply, shall be 120/240 V, 3- wire, single phase, 60 Hz. The LTC control and indicator circuit supply voltage shall be 125 VDC.
- M. Auxiliary Power Supply: Each transformer shall be equipped to accept a 120/240 V, 3-wire, single-phase 60 Hz power supply.
- N. Accessories: Accessories to be furnished with each transformer shall be as listed in Paragraph 2.2.A.10 above, including, but not be limited to, the following:
1. Bottom drain valve and outlet for filter press connection 2-inch (50.8 mm) minimum size globe valve NPT female, with built-in 3/8-inch (9.5 mm) sampling valve. This valve shall be suitable for complete drainage of the tank. Valve shall not be located under radiator banks or be obstructed by other equipment.
 2. Top filter press connection valve, 1-inch (25.4 mm) minimum size, globe NPT female.
 3. 2-inch (50.8 mm) plugs for vacuum connection during vacuum filling, located remote from the top filter press connection.
 4. Top and bottom shut-off valves and drain valve, on conservator tank and each detachable radiator.
 5. Two pads for attaching 107 square mm (No. 4/0 AWG) ground cable to the tank with NEMA standard drilling, located at opposite corners of the tank.
 6. Mechanical pressure-relief device, automatic reseal type, with visual trip target and electrical alarm contacts suitable for 125 VDC.
 7. Magnetic liquid-level indicator with 2 low-level (alarm and trip) contacts suitable for 125 VDC.
 8. An optional gas-sampling valve readily accessible from ground level.
 9. Top-oil temperature indicator, with maximum indicator and two high-temperature (alarm and trip) contacts suitable for 125 VDC.
 10. An optional resistance temperature detector, 3-wire type, 100-ohm platinum at 25 degrees C, for connection to external temperature device.
 11. One hot-spot, four-stage winding-temperature relay with contacts, which upon increasing temperature, will sequentially perform the following functions:
 - a. Energize first stage of cooling equipment (provision).
 - b. Energize second stage of cooling equipment (provision).
 - c. Initiate alarm.

- d. Initiate tripping.
- 12. The set point for each stage shall be independently adjustable, and each stage shall have 2 electrically independent, normally-open contacts rated at 125 VDC.
- 13. Sudden-pressure relay with auxiliary relay and reset push button. The auxiliary relay shall have 2 (alarm and trip) electrically separate terminal contacts wired to the outgoing terminal blocks.
- 14. Transformers with an inert-gas-pressure, oil preservation system shall be provided with a continuously monitoring type, combustible-gas analysis system, with indicating meter and alarm contacts adjustable over the full range. Alarm contacts shall be suitable for 125 VDC. System shall be McGraw Edison Type TCG combustible gas monitor or approved equal.
- 15. Transformers with oil-conservator system shall be provided with Buchholz relay with alarm and trip contacts for suitable 125 VDC.
- 16. Thermostatically-controlled space heaters shall be provided in a readily accessible location in the control cabinets and terminal chambers for the prevention of moisture condensation. When heaters are located where they may be hazardous to operating personnel, they shall be provided with protective screens. Space-heater circuits shall be provided with both a manual and thermostatically-controlled switch. Each heater circuit shall be separately fused and coordinated to maintain selectivity with the main protective device. Space heaters shall be rated 240 VAC and sized for proper heat output when operated at 120 VAC.
- 17. Auxiliary contacts for the above devices shall be rated 2A at 125 VDC. Sufficient contacts for alarm, data logging and shutdown functions shall be provided in addition to the number of electrical independent contacts required for control circuitry. If standard supervisory devices do not have the number of contacts required for control indication, auxiliary relays may be used for contact multiplication. These relays shall be included and installed in the transformer control cabinet.
- O. Finish: Equipment shall be cleaned, primed, and finish painted in accordance with the manufacturer's standard specifications, suitable for outdoor service. A reasonable quantity of touch-up paint shall be provided. The color of the exterior finish paint shall be light gray or equal unless otherwise directed by the Caltrain. Interior control cabinet finish shall be off-white or light gray.
- P. Provide 250 kV BIL and 27.5 kV phase to ground, 100 nF Power Surge Capacitor on the secondary side of the transformer connected between phase to ground.

2.09 NAMEPLATES

- A. Durable corrosion resistant metallic diagram nameplates shall be provided in accordance with ANSI Standard C57.12.00. The nameplates shall also bear the

purchase order number and purchase order item number.

- B. Each control device shall be provided with a suitable nameplate giving the device name plus the ANSI C37.2 device number. The nameplates shall be brass, stainless steel, or laminated plastic with engraved letters.
- C. Each device in the control cabinets shall be provided with an engraved laminated plastic or stainless steel nameplate.

2.10 SPARE PARTS LIST

The manufacturer shall submit a recommended spare parts list and special tools list.

2.11 SHIPPING REQUIREMENTS

Transformer shipments shall be monitored by impact recorders. Impact recorders shall be 30-day dual motion devices, which shall be installed and securely sealed at the factory prior to shipment. These recorders will be opened and inspected prior to unloading the transformer from the railcar or truck. Prior to unloading, pressure and dew point of the inert gas used in shipment shall be measured and recorded. Physical inspections and tests shall be conducted as indicated in Section 34 31 76, TPF Testing and Commissioning. Verify all current transformers are short circuited prior to shipping. Windings shall be prepared for shipping based on manufacturer's recommendations.

2.12 OTHER REQUIREMENTS

Transformers shall be in compliance with all other applicable technical specifications, design criteria, and drawings in the RFP.

Transformers and their hardware shall be designed for zone 4 seismic environment.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Each outdoor type power transformer shall be installed on pad in accordance with manufacturer's instructions and as indicated on the Contract Drawings.
- B. Ground the power transformer to conform to Section 34 31 16, TPF Grounding and Bonding.
- C. Connect wiring to conform to Section 34 31 13, Basic TP Materials and Methods.

END OF SECTION

SECTION 34 31 36

AUTOTRANSFORMERS

PART 1 - GENERAL

1.01 SCOPE

- A. The work of this Section consists of designing, manufacturing, furnishing, factory testing, delivering, installing, and field testing 10 MVA, 55/27.5 kV rated voltage, oil immersed ONAN type Autotransformer units for outdoor installation at the Project's paralleling stations and switching station.
- B. All 10 MVA Autotransformers provided under this contract shall be identical.

1.02 REFERENCE STANDARDS

- A. American National Standards Institute (ANSI – some of the C Series of Standards listed herein are also IEEE Standards):
 - 1. B.1.1 Unified Inch Screw Threads (UN and UNR Thread forms)
 - 2. B1.13M Screw Thread Gauging Systems for Dimensional Acceptability # Inch and Metric Screw Threads
 - 3. C2 National Electrical Safety Code
 - 4. C29.1 Electrical Power Insulators – Test Methods
 - 5. C29.7 Wet Process-Porcelain Insulators-High-Voltage Line – Post Type, including Supplement C29.7a
 - 6. C29.9 Wet-Process Porcelain Insulators (Apparatus, Post Type)
 - 7. C37.2 Electric Power System Device Function Numbers and Contact Designations
 - 8. C37.90 Relays and Relay Systems Associated with Electric Power Apparatus
 - 9. C39.1 Requirements for Electrical Analog Indicating Instruments
 - 10. C57.12.00 Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
 - 11. C57.12.10 American National Standards for Transformers – 230 kV and Below 833/958 through 8,333/10,417 kVA, Single-Phase, and 750/862 through 60,000/80,000/100,000 kVA Three-Phase, without Load Tap Changing; and 2,750/4,687 Through 60,000/80,000/1000,000 kVA with

Load Tap Changing – Safety Requirements

- | | | |
|-----|-----------|---|
| 12. | C57.12.28 | Standard for Pad-Mounted Equipment – Enclosure Integrity |
| 13. | C57.12.70 | Terminal Markings and Connections for Distribution and Power Transformers |
| 14. | C57.12.80 | Standard Terminology for Power and Distribution Transformers |
| 15. | C57.12.90 | Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers and Guide for Short-Circuit Testing of Distribution and Power Transformers |
| 16. | C57.19.00 | General Requirements and Test Procedures for Power Apparatus Bushings |
| 17. | C57.91 | Guide for Loading Mineral Oil Immersed Transformers (Including Corrigendum 1) |
| 18. | C57.93 | Guide for Installation of Liquid Immersed Power Transformers |
| 19. | C57.98 | Guide for Transformer Impulse Tests |
| 20. | C57.100 | Standard Test Procedures for Thermal Evaluation of Liquid-Immersed Distribution and Power Transformers |
| 21. | C57.106 | Guide for Acceptance and Maintenance of Insulating Oil in Equipment |
| 22. | C57.119 | Recommended Practice for Performing Temperature Rise Tests on Oil- Immersed Power Transformers at Loads beyond Nameplate Ratings |
| 23. | C57.123 | Guide for Transformer Loss Measurements |
| 24. | C57.136 | Guide for Sound Level Abatement and Determination for Liquid Immersed Power Transformers and Shunt Reactors |
| 25. | C62.11 | IEEE Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits |
| 26. | C84.1 | Voltage Ratings for Electrical Power Systems and Equipment (60 Hz) |

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

- | | | |
|----|------|---|
| 1. | D117 | Standard Guide for Sampling, Test Methods, Specifications, and Guide for Electrical Insulating Oils of Petroleum Origin |
|----|------|---|

2. D1816 Test Method for Dielectric Breakdown Voltage of Insulating Oil of Petroleum Origin Using VDE Electrodes
 3. D3487 Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus
- C. Institute of Electrical and Electronics Engineers (IEEE):
1. 48 Standard Test Procedures and Requirements for 2.5 kV through 765 kV Alternating-Current Cable Terminations
 2. 516 IEEE Recommended Practices and Requirements for Harmonic Control in Electric Power Systems
 3. 693 Recommended Practices for Seismic Design of Substations
 4. 980 Guide for Containment and Control of Oil Spills in Substations
 5. C57.13 IEEE Standard Requirements for Instrument Transformers
- D. National Electrical Manufacturers' Association (NEMA):
1. BU 1 Busways
 2. EI 21.2 Instrument Transformers for Revenue Metering (125 kV BIL through 350 kV BIL)
 3. ICS 4 Industrial Control and Systems: Terminal Blocks
 4. ICS 6 Industrial Control and Systems: Enclosures
 5. LA 1 Surge Arresters
 6. WC 70 Nonshielded 0-2 kV Cables (ICEA S-95-658)
 7. TR1 Transformers, Regulators, and Reactors
- E. National Fire Protection Association (NFPA):
1. 70 National Electrical Code (NEC)
- F. International Electrotechnical Commission (IEC):
1. 60076 Power Transformers
 2. 296 Insulating Oil (for HV transformers)
 3. 60137 Bushings
 4. 60099-4 Surge Arresters
- G. European Standard (EN):

1. EN 50329:2003+A1:2010 Railway applications. Fixed installations. Traction transformers
- H. American Railway Engineering and Maintenance-of-Way Association (AREMA):
 1. Chapter 33, Part 6 Traction Power Supply Requirements for Railroad AC Electrification Systems.

1.03 RELATED SECTIONS

- A. 34 31 03 - General Traction Power Requirements
- B. 34 31 33 - Traction Power Transformers
- C. 34 31 76 - TPF Testing and Commissioning
- D. 34 31 13 - Basic Traction Power Materials and Methods
- E. 34 31 16 - TPF Grounding and Bonding
- F. 03 11 00 - Concrete Forming
- G. 03 15 00 - Concrete Accessories
- H. 03 20 00 - Concrete Reinforcing
- I. 03 30 00 - Cast-in-Place Concrete
- J. 03 35 00 - Concrete Finishing
- K. 05 12 10 - Structural Steel Framing
- L. 05 50 00 - Metal Fabrications
- M. 09 90 00 - Painting and Coating

1.04 SERVICE CONDITIONS

The transformers shall be suitable for operation at rated MVA under the following conditions:

- A. Ambient Temperature Ranges:
 1. Minimum temperature -10 degrees C (15 degrees F)
 2. Maximum daily temperature +42 degrees C (108 degrees F)
- B. Current and Voltage Distortion: The manufacturer shall consider the specific harmonic content of the traction load in the design and testing of the autotransformer units.

1.05 BASIS OF AUTOTRANSFORMER RATING

- A. The Autotransformer shall have a continuous rating of 10 MVA within the specific temperature- rise limitations and within the limitations of the established standards.
- B. The Autotransformers will be subject to severe working conditions arising from repetitive short circuits on the overhead contact system. These frequent short circuits may vary in amplitude and duration. The manufacturer shall consider at least 360 short-circuits per year without exceeding the normal loss of life expectancy. The Autotransformers will be subject most frequently to unbalanced short circuits (catenary-to-ground). Consequently, Autotransformer cores shall be of augmented mechanical strength and shall include a strengthened internal bracing system for all windings; a magnetic path type core is preferred to a single limb design if a core type Autotransformer is proposed. The Autotransformers shall be carefully designed and built to withstand the inherent severe mechanical and thermal stresses generated due to repetitive fault conditions.
- C. The Autotransformers will be subject to widely varying load magnitudes resulting in pulsating forces inherent to traction power systems. These forces shall not impair Autotransformer performance and shall not cause the Autotransformers to exceed the normal loss of life.
- D. The manufacturer shall perform an engineering design study that includes the following:
 - 1. Hottest spot conductor, top oil and average winding temperature profiles (over 24 hours) shall be provided on the basis of daily load profiles. Temperature rises shall not exceed the limits specified in Paragraph 2.1.A.1. A detailed thermal analysis shall be submitted for approval by Caltrain, to verify that winding hottest spot temperature and the normal loss of life are not exceeded.
 - 2. On the basis of the continuous MVA rating, the manufacturer shall perform a thermal analysis reflecting the overload capability specified in Paragraph 2.1.A.1. Other equipment shall withstand this overload criterion. Winding and oil temperatures (average and hot spot) shall not exceed the limits specified. Calculations shall be submitted for approval by Caltrain. A temperature rise design test shall be performed on the first Autotransformer unit. Test results shall be compared to the calculation results.
 - 3. The manufacturer shall provide detailed loading capabilities of the Autotransformer for various ambient temperatures and load cycles.
- E. Temperature References and Daily Load Profiles: The oil flash point shall not be less than 145 degrees C. The manufacturer shall provide the oil critical flash point and other pertinent oil characteristics.
- F. Temperature References Continuous MVA Ratings: The continuous rated power shall be referenced to an average ambient temperature of +40 degrees C and an average winding temperature rise not exceeding 55 degrees C. For this given condition, the winding continuous hottest spot temperature rises over ambient shall not exceed +80 degrees C.

- G. Temperature References and Temperature Rise Design Tests: The average winding temperature rise shall not exceed +55 degrees C at continuous rated power. In addition, the Autotransformers shall withstand an immediate increase to 150% percent of rated MVA for 1 hour with an average winding temperature rise not to exceed 75 degrees C. During this loading cycle, the maximum winding hottest-spot temperature rise over ambient shall not exceed +80 degrees C by resistance.
 - 1. The manufacturer may propose an alternative temperature rise design test utilizing the equivalent RMS loading for the load cycle indicated in this paragraph. If an alternative is proposed, manufacturer shall submit the cost deduct and the specifics of the alternative test with the quotation.
- H. The manufacturer shall certify that the Autotransformers will comply with the above engineering requirements.
- I. Caltrain requires a model of the transformer as a function of frequency based either on engineering calculations or SFRA open and short circuit measurements. The model shall be suitable for use in the Electromagnetic Transients Program or equivalent. The purpose of this model is to include the effects of transformer impedance variation with frequency for train generated harmonics in the audio frequency range. These harmonics may have an impact on the utility network as well as track circuit equipment.
 - 1. Bidders shall state how the model is proposed to be developed and when this model will be provided.

1.06 DESIGN LIFE

The Autotransformer shall have a design life not less than 40 years. The manufacturer shall provide sufficient supporting data in this regard to the satisfaction of Caltrain.

1.07 SUBMITTALS

- A. In addition to the submittals specified in Section 34 31 03, for Autotransformers, provide design calculated values, shop drawings, and data that include the following:
 - 1. Autotransformer impedance.
 - 2. Autotransformer test plan and detailed procedure including design and routine test.
 - 3. Nameplate data.
 - 4. Hydraulic diagram including location of valves and joints.
 - 5. Transport and delivery plan.
 - 6. Transformer foundations.
 - 7. Transformer oil containment arrangements.

8. Calculation of transformer insulation life.
 9. Bill of Materials (with manufacturer and manufacturers' model numbers in Microsoft Excel spreadsheet format.)
 10. Product data including current transformers, surge arresters, protective devices and instruments, and other appurtenances as required in the specification.
 11. Seismic qualifications report.
- B. Provide the following information with the quotation:
1. Transformer weight.
 2. Transformer outline dimensions with and without radiators.
 3. Cooling oil capacity in gallons.
 4. Any deviations from the specification.

PART 2 - PRODUCTS

2.01 RATINGS

- A. Each Autotransformer shall be capable of the single-phase kVA specified herein when operating outdoors. Autotransformers shall be suitable for railroad duty.
1. Rated Power:
 - a. X1-X2: 10,000 kVA continuous, self-cooled
 - b. X1-X0: 5,000 kVA continuous, self-cooled
 - c. X2-X0: 5,000 kVA continuous, self-cooledMaximum Continuous Winding Temperature
Rise over Ambient:
 - a. With 100% load: 55 degrees C
 - b. Followed by +150% Rated Power for two hours: 65 degrees C
 - c. Followed by +300% Rated Power for 5 minutes: 75 degrees C
 2. Voltage rating:
(The mid-point is connected to the rails and permanently grounded.)55/27.5 kV
 3. Phase: Single
 4. Frequency: 60 Hz

5. Windings: Copper
6. Impedance: Not to exceed 1.2 percent maximum on 12,000 kVA Base. Impedance tolerances shall be in accordance with applicable ANSI/IEEE C57 standards.
7. Cooling: Oil-immersed, Self cooled (ONAN)
8. BIL:

Power Bushing	250 kV (L-G) Minimum Clearance Distance
Between Bushings	635 mm (25 inches)
Ground Bushing	15 kV
9. Sound Level: Not to exceed 68 dBA (NEMA Standard TR1)

2.02 WINDING DESIGN

The winding design shall be such that a 10 percent increase in volts per turn shall not result in core saturation, significant increases of iron losses, noise level, or overheating of the laminations. The manufacturer shall provide the nominal flux density in Tesla at the nominal primary 60 Hz voltage, for the proposed core steel material.

2.03 SHORT CIRCUIT WITHSTAND CAPABILITY

The Autotransformers shall be designed and constructed to withstand the repetitive mechanical and thermal stresses as specified in Paragraphs 1.3 and 1.4, including the impact the existence of a multi-shot autoreclosing scheme. The manufacturer shall submit certified short circuit test results for an equivalent Autotransformer, if available. If the type test certificate is judged inappropriate by Caltrain, a short circuit type test shall be performed on the first unit by an independent test laboratory. The procedure shall be agreed upon between Caltrain and the manufacturer. A detailed test procedure shall be provided for approval by Caltrain.

2.04 GROUNDING

The Autotransformer tank and all associated metallic equipment shall be permanently grounded with a minimum of 2 ground pads in compliance with the substation grounding system.

2.05 OIL CONTAINMENT

- A. Transformer oil containment structure shall have an open area covered with non-skid galvanized steel grating on all sides of the transformer concrete pad as shown in the Contract Drawings.

- B. At one corner of this structure a sump shall be provided as shown on the Contract Drawings. All 4 sides shall slope 1 percent minimum towards the sump.
- C. Interior surface of the containment basin shall be painted with epoxy primer and polyurethane finish coat.
- D. Waterstops shall be provided at the construction joints as shown in the Contract Drawings.
- E. Structural steel beams shall support the galvanized steel grating.

2.06 CONSTRUCTION DETAILS

- A. General: Autotransformers shall be outdoor type, oil filled, suitable for outdoor unsheltered installation and outdoor ambient temperature range from minus 10 degrees C to +42 degrees C.
- B. Tank:
 - 1. Autotransformers shall have a welded steel tank for preservation of the transformer oil. The cover will be bolted together with the tank walls through a special flange with stainless steel screw and nuts. The tank shall be provided with lifting lugs suitable for use with slings and cables. The tank shall be designed for vacuum filling with transformer oil.
 - 2. The tank cover shall be provided with one or more manholes with covers, and furnished with lifting lugs. Manholes shall be not less than 21 inches (534 mm) diameter.
 - 3. The manhole or manholes shall afford easy access to the lower ends of the bushings, the terminals, and the upper portions of the coils, and to permit replacement of current transformers and other auxiliaries without removing the tank cover.
 - 4. No manhole shall be located in such a position as to require removal of radiators or other parts or accessories to secure access.
 - 5. All piping to the radiators shall be furnished with shut-off valves and blind flange covers.
 - 6. Covers for all bushing holes shall be furnished with the tank.
 - 7. The base shall be fabricated steel, designed for skidding.
 - 8. The base shall have provision for jacking the complete transformer, and shall have two welded-on ground pads for grounding the tank, diametrically located at corners.
- C. Bushings:

1. The bushings shall be cover or side mounted, as shown on the Contract Drawings, paper oil condenser type, in totally enclosed light gray porcelain housing, oil filled end to end. Bushings shall meet all ANSI and IEEE Standards for outdoor apparatus for the required voltage rating (ANSI C57.12.00, Section 6.1).
2. The bushings shall be rated 27.5 kV each. Bushings shall be provided with two bushing - type current transformers on each bushing. They shall be C400 in accordance with ANSI C57.13, one with ratio 600:5 and second with 1250:1.
3. The mid-point of the winding shall be insulated from the tank and brought through the cover via a 15 kV bushing for connection to rails and ground. Provide one bushing type current transformer. The CT shall be 1200:5, C400 in accordance with ANSI C57.13.
4. The bushings shall be furnished with 4-hole NEMA pad terminals for cable/bush connectors.
5. Insulation Levels:

Low Frequency kV rms:

High Voltage Bushing	95 kV
Center Bushing	34 kV

Full Wave Impulse Crest Voltage:

High Voltage Busing	250 kV
Center Bushing	110 kV

Chopped Wave kV Crest:

High Voltage Bushing	275 kV
Center Top Bushing	120 kV

- D. Accessories: Provide accessories in accordance with Paragraph 2.8.N.1 through 2.8.N.17 of Section 34 31 33 Traction Power Transformers.
- E. Finish: Equipment shall be cleaned, primed and finish painted in accordance with the manufacturer's standard specifications, suitable for outdoor service. A reasonable quantity of touch-up paint shall be provided. The color of the exterior finish paint shall be ANSI 61 light gray or equal unless otherwise directed by the Caltrain. Interior control cabinet finish shall be off-white or gray.
- F. Core and Coils: Provide Core and Coils in accordance with Paragraph 2.8.F of Section 34 31 33 Traction Power Transformers.
- G. Transformer Insulating Oil: Provide transformer insulating oil in accordance with Paragraph 2.8.G of Section 34 31 33 Traction Power Transformers.

- H. Oil Preservation Equipment: Provide oil preservation equipment in accordance with Paragraph 2.8H of Section 34 31 33 Traction Power Transformers.
- I. Cooling Equipment: Provide cooling equipment in accordance with Paragraph 2.8.I of Section 34 31 33 Traction Power Transformers.
- J. Control, Auxiliary Power, Instrument, and Alarm Wiring: Provide control, auxiliary power, instrument, alarm wiring, and control cabinet in accordance with Paragraph 2.8.K of Section 34 31 33 Traction Power Transformers.
- K. Auxiliary Power Supply: Auxiliary power supply provisions shall be in accordance with Paragraph 2.8.M of Section 34 31 33 Traction Power Transformers.
- L. Surge Arresters:
 - 1. Metal Oxide Surge Arresters (Intermediate Class): Surge arrester protective characteristics shall coordinate with transformer insulation to give satisfactory protection to the traction power transformer per IEEE C62.11, IEEE 1313.2 and NEMA LA1. Surge arrestors and surge counters shall be appropriately insulated from the autotransformer with the following ratings:

Service	2 x 27.5 kV SYSTEM Autotransformer
Rated Frequency, Hz	60
System Maximum Voltage, kV	29 (L-G)
Rated Voltage, kV	45
Maximum Continuous Operating Voltage (MCOV), Line to Ground, kV	36
Pressure Relief Device, kA, rms	40

2.07 NAMEPLATES

- A. Durable corrosion-resistant metallic diagram nameplates shall be provided in accordance with ANSI standards. The nameplates shall also bear the purchase order number and purchase order item number.
- B. Each control device shall be provided with a suitable nameplate giving the device name plus the ANSI device number. The nameplates shall be stainless steel with engraved letters.
- C. Each device in the control cabinets shall be provided with an engraved laminated plastic or stainless steel nameplate.

2.08 SPARE PARTS LIST

The manufacturer shall submit a recommended spare parts list and special tools list.

2.09 SHIPPING REQUIREMENTS

SECTION 34 31 39**CONTROL AND INDICATION PANELS****PART 1 – GENERAL****1.01 SCOPE**

- A. The work of this Section consists of furnishing factory wired control and indication panels and associated control devices, relays and instruments as required for the local/remote control and supervision of a Traction Power Facility (TPF). The TPF could be a Traction Power Substation (TPS), Switching Station (SWS), or Paralleling Stations (PS) as directed by Caltrain. This equipment shall be installed in the prefabricated switchgear and control building enclosures specified in Section 34 31 89.
- B. The work of this section shall be coordinated with the requirements of the TPS SCADA system, as shown on the Contract Drawings, and specified in Section 34 31 11. 115 kV and 25 kV control panels will be installed in TPS, SWS and PS control rooms (and not in WPC), to be used as a back-up for local control via the SCADA HMI.
- C. Control panel related circuitry for the 115kV portion of the system shall meet PG&E interconnection requirements.

1.02 RELATED SECTIONS

Related requirements are included in, but not limited to, the following Sections:

- A. 34 31 03 - General Traction Power Requirements
- B. 34 31 09 - Supervisory Control Interface Terminal Cabinet
- C. 34 31 11 - Substation Supervisory Control and Data Acquisition (SCADA) System
- D. 34 31 13 - Basic Traction Power Materials and Methods
- E. 34 31 47 – Indoor Gas Insulated 27.5 kV Switchgear
- F. 34 31 48 - Indoor Solid Insulated 27.5 kV Switchgear
- G. 34 31 89 - TPF Enclosures

1.03 REFERENCE STANDARDS

- A. American National Standards Institute (ANSI):
 - 1. C2 National Electrical Safety Code
 - 2. C37.2 Electric Power System Device Function Numbers and Contact Designations

3. C37.90 Relays and Relay Systems Associated with Electric Power Apparatus
4. C39.1 Requirements for Electrical Analog Indicating Instruments
- B. Institute of Electrical and Electronics Engineers (IEEE):
 1. C37.90.1 IEEE Standard Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems
 2. C37.90.2 IEEE Standard for Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers
 3. 693 Recommended Practices for Seismic Design of Substations
- C. International Electrotechnical Commission (IEC):
 1. 60255 Electrical Relays
- D. Instrument Society of America (ISA):
 1. S18.1 Annunciator Sequences and Specifications
- E. National Electrical Manufacturers' Association (NEMA):
 1. 250 Enclosures for Electrical Equipment (1000 Volts Maximum)
 2. ICS 1 Industrial Control and Systems: General Requirements
 3. ICS 4 Industrial Control and Systems: Terminal Blocks
 4. ICS 6 Industrial Control and Systems: Enclosures
- F. National Fire Protection Association (NFPA):
 1. 70 National Electrical Code (NEC)
- G. American Iron and Steel Institute (AISI):
 1. C1010 Steel Products Manual-Carbon Sheet Steel
- H. European Standard (EN):
 1. EN 50121-5 Railway applications - Electromagnetic compatibility - Part 5: Emission and immunity of fixed power supply installations and apparatus.

1.04 SUBMITTALS

- A. Shop Drawings and Product Data: Site specific shop drawings and product data shall be submitted in accordance with Section 34 31 03, and shall include the following:

1. Dimensioned outline drawings for each item of equipment.
2. Cross sectional drawings of each item of equipment.
3. Component and/or detail drawings.
4. Assembly and/or erection drawings of all components.
5. Technical data and catalog cuts of all protective relay, meters, auxiliary relays and devices, AC and DC power distribution panels, and all other major units and subsystems.
6. Panel layouts showing locations of all control and protective devices, meters, and 115 kV and 25 kV system mimic buses. The plan and elevation drawings should show sufficient detail of the layout of all equipment in each panel.
7. Control schematic diagrams and wiring diagrams of all equipment showing internal wiring and terminal block arrangement and identification of each outgoing power and control terminal. All devices shall be shown in their respective physical locations.
8. Interconnection diagrams showing terminal blocks of individual units and interconnections between units. All devices shall be shown in their respective physical locations. Wire numbering shall be point to point.
9. Test certificates for relays demonstrating compliance with EN 50121-5, IEEE C37.90.1 and IEEE C37.90.2.

PART 2 – PRODUCTS

2.01 GENERAL

- A. Control and indication panels shall be provided for the local control and indication of at a TPF equipment including gantry-mounted motor operated disconnect switches
- B. Control and indication panels will be integrated with the overall substation control system, including SCADA system interface.
- C. The general contents of the control and indication panels to be provided for the TPS, SWS and PS for this Contract are as follows.
 1. 115kV Relay Panel (One panel per incoming line, only used at TPS)
 - a. 115 kV circuit breaker controls and relays (for two incoming lines).
 - b. Traction power transformers: control and indication only (protective relays 86T and 87T shall be located in the switchgear control compartments).
 2. Mimic Panels (One panel per SWS, TPS, and PS):

- a. Autotransformer and 2 x 25 kV autotransformer secondary circuit breakers: control and indication only (protective relays shall be located in the switchgear control compartments).
- b. 25 kV bus tie, OCS and autotransformer feeder circuit breakers: control and indication only (protective relays shall be located in the switchgear control compartments).
- c. Gantry-mounted MODs: Control and indication.
- d. Mimic panel control, indication and lockout for the above items.
- e. Equipment layout and order of devices on the Mimic panel layout shall match the field physical layout.

2.02 CONTROL AND INDICATION PANELS - GENERAL

- A. Control and indication panels shall be located as shown on the Contract Drawings and shall be metal enclosed, indoor type structures, factory assembled and tested, containing the equipment and devices as specified herein and shown on the Contract Drawings.
- B. Control and indication panels shall be completely enclosed on the top, the bottom and all sides, designed for free-standing installation.
- C. Control and indication panels shall be constructed from highest quality hot-rolled, pickled and oiled sheet steel equal to AISI alloy C1010, AISI carbon sheet steel. Front and rear panels shall be constructed from No. 11 gauge steel minimum. Side sheets and top members shall be constructed from No. 13 gauge steel minimum. Suitable stiffeners shall be used to prevent warping. Mimic panels may be aluminum.
- D. Adequate ventilating openings complete with filters located behind each opening to retard the entrance of dust, foreign matter, insects, and rodents shall be provided if suggested by manufacturer.
- E. Control and indication panel wiring shall be factory installed, Type SIS cross-linked polyethylene, 600 V, tinned copper. Control and indication wiring and voltage transformer circuit wiring shall be stranded 14 AWG minimum. Current transformer circuit wiring shall be stranded 10 AWG minimum. Wiring shall be firmly fixed in place with clamps of a type which will not damage insulation. Wiring shall be neat, with all wires grouped as much as possible. Ring type solderless terminal connectors of the heavy duty insulated type shall be used on all CT connections. Control wiring will utilize fork lugs. Wiring associated with meters and transducers shall be arranged to permit the testing and calibration of the associated devices through built in or panel mounted test blocks on PT and CT circuits.
- F. Terminal blocks shall have screw type terminal capable of receiving two solid copper wires. Twenty percent spare unassigned terminals are required. All terminal blocks shall be furnished with marking strips for wire identification. All devices shall be identified on the rear of the panel by device number. All incoming wires to the control panel shall terminate on a terminal strip. Provision

for field wiring entry shall be made. All meters and relays shall be wired through suitable panel mounted test blocks. Test blocks shall be GE Type PK-2 or approved equal, with potential and/or current terminals, as required.

G. Mimic Bus:

1. The mimic bus shall be made of anodized aluminum or plastic sheeting. The size and proportions of the figures and the overall mimic bus layout shall be submitted to Caltrain for approval.
2. Mounting shall permit changes and replacement, but screw, rivet, or bolt heads shall not show on the panel faces or the face of the mimic bus.
3. Colors shall be red for the 25 kV components and green for 25 kV motorized disconnect switches and components. Mimic bus colors shall be uniform and vivid. 115kV and 25kV are to be separate panels.
4. The outline, surface, and finish of the mimic bus shall be smooth, without irregularities or blemishes.

H. Nameplates:

1. Nameplates shall be provided for each relay and device to identify its function and, where applicable, its position.
2. Nameplates shall be in accordance with the requirements of Section 34 31 03, Paragraph 2.3.

I. Painting:

1. Enclosure and finished metal surfaces shall be painted ANSI light gray in accordance with the requirements of Section 34 31 03.

J. Panels shall be terminated and fully dressed with proper wire/cable management. Carefully bundle, twist, shield, protect, route, and properly terminate high current cables such as motor operated disconnect power cables, to minimize uncontrolled emissions. Verify that the cable installation does not exceed the minimum bend radius for the cable. Connect low voltage cable shields to the appropriate low voltage ground at the source and, per IEEE Std 1100, sections 3.3 and 8.5 and IEEE Std 1143, section 7, to the receiver-end equipment.

K. Where indicated on the Contract Drawings, provide power receptacles in accordance with the requirements of Section 34 31 13.

2.03 115/25KV CONTROL PANELS

A. Relays:

1. Protective relays shall be located in their respective switchgear sections.
2. Protective relays are identified on relay and metering full line diagrams

per IEEE Standard C37.2 "IEEE Standard Electrical Power System Device Function Numbers." The selection of correct range of operation of the relay shall be the responsibility of the Contractor. The relays shall be single phase unless otherwise noted. Types and typical equipment are outlined as follows:

- a. Device No 21 - Directional Distance Relay for catenary and autotransformer feeder protection
- b. Device 26Q - Transformer Liquid Temperature Relay
- c. Device No. 27 – Undervoltage Relay
- d. Device No. 27H – High Set Undervoltage Relay
- e. Device No. 49T – Transformer Thermal Relay, factory adjusted, for use with resistance temperature detectors
- f. Device No. 49CAT – Catenary Overload Thermal Replica Relay
- g. Device No. 50/27 – Switch Onto Fault Relay
- h. Device No. 50/51 – Time Overcurrent with Instantaneous Attachment Relay
- i. Device No. 51 – Time Overcurrent Relay
- j. Device No. 50BF – Breaker Failure Fault Detector Relay
- k. Device No.62 – Time Delay Relay, adjustable
- l. Device No. 63 – Sudden Pressure Relay, factory furnished and adjusted
- m. Device No. 67 – AC Directional Overcurrent Relay with voltage polarization
- n. Device No. 71Q – Level Switch, Transformer Oil Level, factory furnished and adjusted
- o. Device 79 – Reclosing Relay, multi-shot designed to automatically reclose a circuit breaker which has been tripped by devices 21MZ or 51L
- p. Device 86 – Lockout Relay, hand-reset by pistol-grip handle, complete with amber indicating LED
- q. Device 86TG – Lockout Relay, electrically and hand operated type -oval handle, complete with red flag to denote when in Tag Applied position.
- r. Device Nos. 87B – Bus Differential Relay, low impedance
- s. Device No 87T, 87AT – Transformer differential relay with

second harmonic restraint

3. Mounting: Protective relays shall be mounted on control panels, relay panels and switchgear enclosures as shown on the Contract Drawings and as specified herein.
 4. EMI Immunity: Protective relays shall meet the requirements of EN 50121-5. Submit test certificates for review.
- B. Control and transfer switches shall be provided in accordance with the requirements of Section 34 31 03.
- C. Indicating lamps shall utilize light emitting diodes (LED).
- D. Instruments:
1. General: Instruments shall meet the requirements of ANSI C39.1 for electrical indicating switchboard instruments, accuracy class 1. Meters shall be of the solid state digital monitor design for switchboard application. Units associated with analog input to an RTU may include the transducer outputs in lieu of separate transducers. Meter characteristics shall be as follows:
 - a. Maximum continuous input voltage – 150 V phase to neutral.
 - b. Maximum continuous input current – 10 Amps (programmable to any CT ratio).
 - c. Maximum burden for current circuit – 0.5 VA.
 - d. Maximum burden for voltage circuit – 0.5 VA.
 - e. Surge withstand capability per IEEE/ANSI C37.90.1.
 - f. Operating temperature – 20°C to 70°C.
 - g. Control power requirement – 6 VA max at 120 VAC.
 - h. Construction – metal housing with standard switchboard dimensions and cutout.
 2. Auxiliary Potential Transformers: Transformers shall be suitable for line-to line or line to- ground connections on the primary supply and suitable for switchboard use. Transformers shall be rated 120/120 V, 60 Hz (1:1 voltage ratio). 500 VA (30 °C), 10 kV BIL (600 V class), conforming to ANSI C57.13, with accuracy and burden rating 0.3W, X,M.
- E. Transducers: Transducers shall be rated 5 A and 115 V input, suitable for switchboard mounting or alternately integral components of the associated panel mounted meter. Associated current transformer and potential transformer ratios shall be as shown on the Contract drawings. Output shall be 0-20 mA or as required for SCADA system input. Output range related to

primary input shall be in accordance with the RTU point list. Transducer characteristics shall be as follows:

1. Accuracy 0.5% of rated output.
2. Maximum continuous input voltage – 150 V phase to neutral.
3. Maximum continuous input current – 10 Amps.
4. Maximum burden for current circuit - <0.5 VA.
5. Maximum burden for voltage circuit - <0.5 VA.
6. Surge withstand capability (SWC) per ANSI/IEEE C37.90.1 and ANSI/IEEE C37.90.2.
7. Minimum input/output isolation – 1,500 VAC, 60 Hz.
8. Construction – metal housing with standard switchboard dimensions and cutout per ANSI 39.1.
9. All wiring of instrument transformer circuits to transducers shall be through approved instrument transformer test switches.

2.04 COMMUNICATIONS INTERFACE CABINET

- A. Provide provisions for communications rack for installation of communications equipment. Provisions for grounding and AC and DC power supply as required shall be provided.

2.05 POWER QUALITY METERS

- A. Provide Power Quality Metering Devices at TPS for each incoming 115kV line as shown on the contract drawings and specified by PG&E requirements.
- B. Power Quality Meter shall be PQube3 or approved equivalent and shall include test switches.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Install the specified 115kv relay and mimic panels within each substation enclosure secure, plumb and level and in true alignment with related adjoining work.
- B. Install supporting members, fastenings, framing hangers, bracing, brackets, straps, bolts, and angles as required to set and rigidly connect the work.

END OF SECTION

SECTION 34 31 43

OUTDOOR INSTRUMENT TRANSFORMERS

PART 1 - GENERAL

1.01 SCOPE

- A. The work of this Section consists of manufacturing, testing and installation of instrument transformers, including 115 kV and 27.5 kV voltage transformers, and bushing type current transformers.

1.02 REFERENCE STANDARDS

- A. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. C57.13 IEEE Standard Requirements for Instrument Transformers
 - 2. 242 IEEE Recommended Practice for Protection and Coordination of Power Systems
- B. European Standards (EN):
 - 1. 50152 Railway Applications–Fixed Installations–Particular Requirements for AC Switchgear Part 1: Single-phase circuit-breakers with Um above 1 kV.

1.03 RELATED SECTIONS

Related requirements are included in, but not limited to, the following Sections:

- A. 34 31 03 - General Traction Power Requirements
- B. 34 31 13 - Basic Traction Power Materials and Methods
- C. 34 31 47 - Indoor Gas Insulated 27.5 kV Switchgear
- D. 34 31 53 - 115 kV Circuit Breakers
- E. 34 31 76 - TPF Testing and Commissioning

1.04 SUBMITTALS

- A. Shop drawings, test reports and other submittals describing the materials to be used shall be submitted to Caltrain prior to installation, in accordance with Section 34 31 03.
- B. Descriptive Data: Submit for approval descriptive data on all materials to be provided under this Section and other designated sections. Data shall be sufficient to indicate conformance to all specified requirements.

- C. Outline drawings for each type of instrument transformer and each shipping section with overall dimensions, sizes and weights.
- D. Shop drawings, including:
 - 1. Nameplate drawings.
 - 2. Ratio correction factor curves and phase angle corrections.
 - 3. Complete assembly drawings showing elevations and section views of each type of instrument transformer.
 - 4. Erection plan drawings showing locations of mounting bolts, and conduit and grounding connection.
 - 5. Complete full-line diagrams and interconnection wiring diagrams including terminal wiring designations.
 - 6. Certified test reports for metering instruments.
 - 7. Submit certified design test data conducted on Capacitive Voltage Transformers of similar type that proves compliance with the specified standards and includes excitation curves and saturation and knee point curves.
- E. Catalog Cuts:
 - 1. Instrument transformer characteristic curves and burden requirements.

1.05 GENERAL CHARACTERISTICS

- A. Devices shall be suitable for outdoor installation on a 115 kV and 2 x 27.5 kV, 60 Hz traction power substation electrical system and to operate properly under the specified ambient conditions and seismic requirements.
- B. Bushing-type current transformers shall have their secondary winding fully distributed on the core. This type of current transformer is for use with a fully insulated bushing and located within the circuit breaker or power transformer. Each current transformer shall be terminated on a dedicated shorting type terminal block. Each multi-ratio current transformer shall have all the taps terminated in a shorting type terminal block.
- C. The instrument transformers shall be designed for use in a UBC seismic Zone 4 environment, and other operating conditions, as specified in Section 34 31 03.
- D. Equipment shall be designed to be in a highly corrosive environment and treated properly due to the high levels of salts in the air.

PART 2 - PRODUCTS

2.01 INSTRUMENT TRANSFORMERS

- A. General:

1. High voltage free standing potential transformers for 115 kV nominal applications shall be of the oil-filled, type for metering and relay applications conforming to IEEE C57.13, Group 3, single-bushing type for connection phase to ground.
2. Medium voltage potential transformers rated 27.5 kV, 60 Hz may be of solid dielectric or cast resin type design. Transformer ratios are shown on the Contract Drawings.
3. Bushing type current transformers shall be of solid dielectric design with 5 Ampere secondary rating. 25 kV bus differential circuits will have a 1 A secondary rating. Secondary winding shall be capable of 100 percent continuous overload.

B. Construction

1. Potential transformer units shall consist of tank and dome fabricated of steel plate, one piece porcelain insulator, oil immersed core and coil assembly, degassed and dehydrated non-PCB insulating oil, with hermetically sealed construction. Non-porcelain insulators may be submitted for Caltrain approval, if required to meet project seismic requirements.
2. Terminal box shall contain clearly marked secondary terminals and shall be weather-tight with tapped conduit openings. Assembly shall be corrosion-resistant with stainless steel hardware and finished in epoxy enamel. Provisions shall be made for expansion of the oil with temperature and for oil filling and draining, and for nitrogen filling. A magnetic type oil level gauge shall be provided.

C. Rating

1. 115 kV Voltage Transformers: 115 kV nominal system voltage, 550 kV BIL, primary voltage 69 kV, secondary voltage 120 volts with 69 volts tap, accuracy 0.3 percent (90 to 110 percent nominal voltage), burden rating W, X, M, Y, Z, ZZ, in accordance with IEEE C57.13.
2. 27.5 kV Voltage Transformers: 27.5 kV nominal system voltage, 250 kV BIL, primary voltage 27.5 kV, secondary voltage 120 volts, accuracy 0.3 percent (90 to 110 percent nominal voltage), burden rating W, X, M, Y, Z, ZZ, in accordance with IEEE C57.13.
3. Bushing current transformers for metering application shall be rated 0.3B2, or in conformance with the power utility company.
4. Bushing current transformers for use in relaying applications shall be of the ratio specified in the contract drawings with the following ratings:

RATIO	ACCURACY CLASS
100:5 to 600:5	C200
700:5 to 1200:5	C400
1,600:5, or higher	C800

1250:1	C400
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2.02 TERMINALS

- A. Potential transformer primary terminal shall be a NEMA four-hole pad and ground connector and a NEMA standard two-hole stainless steel pad with connector for ground cable.

2.03 FREQUENCY RESPONSE CURVE

- A. The frequency response curve shall be provided (60 Hz through 3,000 Hz).

2.04 VOLTAGE TRANSFORMER FUSE CABINETS

- B. All outdoor voltage transformers shall be associated with a fuse cabinet installed at the bottom of the structure.
- C. The equipment shall have a fuse monitoring device Ferraz model A025R, F Bussman series 70, or approval equal. This device shall be associated with Device 27 relays and metering devices. The cabinets shall be in accordance with Section 34 31 13.
- D. Enclosure shall be NEMA 4X, finished with primer and ANSI 61 finished coat.

PART 3 - EXECUTION

- A. Potential transformers and current transformers shall be mounted on the associated supporting structures in accordance with the manufacturer's instructions and as indicated on the Contract Drawings.

END OF SECTION

SECTION 34 31 47**INDOOR GAS INSULATED 27.5 KV SWITCHGEAR****PART 1 - GENERAL****1.01 SCOPE**

- A. The work of this Section consists of the manufacturing, furnishing and factory testing of indoor 2-pole 27.5 kV, gas insulated switchgear for installation in prefabricated switchgear building for traction power substations, switching stations, and paralleling stations.
- B. The 27.5 kV switchgear assembly shall form a dead-front, free-standing, self-supporting lineup. The switchgear shall be configured with two-pole vacuum circuit breakers as indicated on the Contract Drawings.
- C. The switchgear shall be an SF6 Alternative-insulated, type-tested, double-pole metal-enclosed switchgear with fixed-mounted vacuum circuit-breakers and shall be designed for traction power supply systems up to a continuous operation voltage of 27.5 kV.
- D. Relay and control requirements for the 27.5-kV switchgear are specified in Section 34 31 39, Control and Indication Panels.

1.02 REFERENCE STANDARDS

- A. Applicable Standards for 27.5 kV Switchgear: Many American standards do not directly address 27.5 kV single-pole and two-pole switchgear. Applicable European standards (EN and IEC) for 27.5 kV railway switchgear are listed in lieu of American standards.
- B. American National Standards Institute (ANSI)
 - 1. IEEE/
ANSI C57.13 Requirements for Instrument Transformers
- C. International Electrotechnical Commission (IEC)
 - 1. IEC 61869 Instrument transformers
 - a. Part 1: General requirements
 - b. Part 2: Current transformers
 - c. Part 3: Inductive voltage transformers
 - 2. IEC 60376 Specification of technical grade sulfur hexafluoride (SF6) for use in electrical equipment
 - 3. IEC 60529 Degrees of protection provided by enclosures (IP code)
 - 4. IEC 61243 Live working - Voltage detectors
 - a. Part 5: Voltage detecting systems (VDS)

5. IEC 62271 High-voltage switchgear and controlgear
 - a. Part 1: Common specifications for high-voltage switchgear and control gear standards
 - b. Part 100: High-voltage alternating-current circuit-breakers
 - c. Part 102: Alternating current disconnectors and earthing switches
 - d. Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV
 6. IEC 60721 Classification of environmental conditions
 - a. Part 3-3: Stationary use at weatherprotected locations
 7. IEC 60850 Railway applications – supply voltage of traction systems
- D. European Standards (EN):
1. EN 50124 Railway applications - Insulation coordination
 - a. Part 1: Basic requirements; Clearances and creepage distances for all electrical and electronic equipment
 - b. Part 2: Overvoltages and related protection
 2. EN 50152 Railway applications - Fixed installations - Particular requirements for a.c. switchgear
 - a. Part 1: Single-phase circuit-breakers with Um above 1 kV
 - b. Part 2: Single-phase disconnectors, earthing switches and switches with Um above 1 kV
 - c. Part 3: Measurement, control and protection devices for specific use in a.c. traction systems;
 - 1) Part 3-1: Application guide
 - 2) Part 3-2: Single-phase current transformers
 - 3) Part 3-3: Single-phase inductive voltage transformers
 3. EN 50163 Railway applications - Supply voltages of traction systems
 4. EN 50181 Plug-in type bushing above 1kV up to 52 kV and from 250 A to 2.5 kA for equipment other than liquid filled transformers.

1.03 RELATED SECTIONS

- A. Related requirements are included in, but not limited to, the following:
1. 34 31 03 - General Traction Power Requirements
 2. 34 31 13 - Basic Traction Power Materials and Methods

3. 34 31 39 - Control and Indication Panels
4. 34 31 76 - TPF Testing and Commissioning
5. 34 31 89 - TPF Enclosures

1.04 SUBMITTALS

- A. Refer to Section 01 33 00, Submittal Procedures for review process.
- B. Descriptive Data: Submit for Caltrain's approval descriptive data on all equipment to be provided under this Section. Data shall be sufficient to indicate conformance to all specified requirements.
- C. Shop drawings, test reports and other submittals describing the materials to be used shall be submitted to JPB prior to installation in accordance with Section 34 31 03.
- D. Shop drawings of switchgear including:
 1. Mechanical parts and assemblies, including electrical components, complete connection details, torque requirements, as well as a complete list of parts with full identification.
 2. Outline drawings indicating overall dimensions, weights, locations of switchgear devices on the panel, aisle space required for operation of equipment, cable entrances, and reference tables to other drawings furnished.
 3. One-line diagram showing all ratings, main connections, and the locations of all current and potential transformers.
 4. Bus arrangement including bus material, dimensions and ampere rating of all bus bars.
 5. Type and spacing of bus supports.
 6. Maximum short circuit bracing.
 7. Complete assembly drawings showing elevations and section views of each non-identical unit.
 8. Foundation plan drawings showing locations of channel sills, anchor bolts, and conduit and grounding entrances.
 9. Complete full-line diagrams and interconnection wiring diagrams showing all controls and instruments, including terminal wiring designations.
 10. Structure drawings showing available space for all conduit and cable connections.
 11. Schematic (elementary) control diagrams, both AC and DC, for switch control, interlocks, relays and instruments with all terminals identified and indicating the internal wiring for each component and the interconnections between components.

12. Circuit breaker type, interrupting rating, basic impulse level, operating/interlocking logic diagrams.
 13. Rating, sizes and types of cable terminators.
 14. A complete bill of material listing equipment manufacturer, equipment type, ratings, catalog numbers, instrument transformers ratios, and accuracy class, etc.
 15. Test procedures that the manufacturer will perform.
 16. Certified copies of test reports of tests required by applicable IEC/EN and standards.
 17. Shipping and handling instructions with drawings showing lifting devices for unloading.
- E. Catalog Cuts: Provide catalog information for the following as a minimum:
1. Switchgear
 2. Circuit breakers
 3. Protective devices
 4. Control switches
 5. Switchgear lights
 6. Switchgear heaters
 7. Switchgear convenience outlets
 8. Instrument transformer characteristic curves and burdens
 9. Switchgear fuses
 10. Relays and meters
 11. Test switches
- F. Operating and maintenance (O&M) manuals for circuit breakers, relays, meters, transducers, ground and test devices: The manual shall provide comprehensive detailed information on the approved installation, operation and use, troubleshooting, parts list, lubrication and periodic maintenance, source of replacement parts and service for the items of equipment covered. Fifteen copies of O&M manuals shall be submitted by the Contractor to Caltrain.

1.05 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with requirements of the Contract Documents, vendors offering products and services which may be considered for this Project include, but are not limited to, the following:
1. Siemens Transportation Systems

2. ABB Secheron
3. Or approved equal

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

- A. The pre-packaged switchgear shall consist of an assembly of gas insulated, vacuum circuit breaker switchgear and associated components. Switchgear shall be complete with fixed mounted vacuum circuit breakers, current and potential transformers, control switches, indicating lamps, protective apparatus and all other devices as indicated on the Contract Drawings and as required for the intended operation. The switchgear shall be housed in a pre-fabricated switchgear building with integral control room.
- B. The design of the switchgear shall provide features for safety of personnel during operation, maintenance and repair and be constructed in accordance with the applicable requirements of IEC 62271-200.

2.02 EQUIPMENT RATINGS

- A. Voltages
 1. Nominal voltage according to IEC 60850 and EN 50163 25 kV
 2. Rated insulation voltage according to EN 50124 27.5 kV
 3. Rated short-duration power-frequency withstand voltage 95 kV
 4. Rated lightning impulse withstand voltage 200 kV
 5. Rated frequency 60 Hz
- B. Short-circuit values
 1. Rated short-circuit breaking current 25 kA
 2. Rated short-circuit making current (max.) 63 kA
 3. Rated short-time withstand current 25 kA
 4. Rated short-circuit duration 3 s
- C. Current values
 1. Rated normal current of busbar 2000 A
 2. Max. Permissible busbar current at 35 °C 2000 A
 3. Rated normal current of feeder 1250 A
 4. Max. permissible busbar current at 35 °C 1290 A
- D. Rated Supply Voltage
 1. Motor, circuit breaker DC 125 V

2. Control and protection

DC 125 V

2.03 CIRCUIT BREAKER

- A. Circuit-breakers shall be vacuum type. The vacuum circuit-breaker tube shall be located inside the gas filled enclosure.
- B. Vacuum interrupters shall be totally maintenance-free with a mechanical / electrical service life of 20,000 breaking operations at rated normal current and 50 breaking operations at rated short-circuit breaking current of 25 kA.
- C. The operating mechanism of the circuit-breaker shall be placed at the switchgear front and all operations can be carried out from the front of the switchgear panel.
 - 1. The circuit-breaker shall be able to perform up to 10,000 operating cycles without maintenance, even after long periods of standstill.
- D. The operating shaft and the contact pressure springs shall be arranged outside. Circuit- breakers shall be equipped with:
 - 1. Stored-energy spring mechanism with motor, capable of auto-reclosing
 - 2. Mechanical ON and OFF push buttons
 - 3. Closing solenoid
 - 4. Shunt release
 - 5. Counter for operating cycles
 - 6. Auxiliary switch 12NO + 12NC
 - 7. Auxiliary switch for "spring-charged" indication
- E. The manometer for gas monitoring of the circuit-breaker gas compartment shall be placed below the operating mechanism of the three-position disconnecter and must be visible from the panel front.

2.04 SWITCHGEAR ASSEMBLY

- A. The switchgear assembly shall be furnished complete with fuses, potential transformers, current transformers, auxiliary power receptacles, heaters, and other accessories as shown on the Contract Drawings, as specified in this Section and as required to provide a complete and operable switchgear assembly.
- B. Switchgear units shall be constructed as individual free-standing dead front type panels. Each panel shall be a structurally rigid self-supporting unit complete with control panel and circuit breaker. All steel work shall be carefully finished to remove all sharp edges, rust-proofed and treated for improved paint adhesion. The units shall be uniform in height and aligned in front.
- C. All high-voltage conductors and interrupter elements shall be hermetically enclosed in two cast aluminum alloy housing which are safe to touch.

1. The upper housing shall contain the copper busbar mounted on epoxy insulators and the three-position disconnecter.
 2. The other housing shall contain the vacuum tube of the circuit-breaker.
 - a. Both housings shall be sealed against each other by arc-proof and gas-tight epoxy bushings.
 - b. Power cables shall be connected to the circuit-breaker housing.
 - c. Cable connection shall be located at the bottom area of each panel.
 3. Current transformers shall be arranged outside the primary enclosure (CB housing).
 - a. The feeder related protection devices and auxiliary relays shall be installed in a metal-clad low-voltage cabinet on top of each panel.
- D. Housings shall be made of corrosion-resistant aluminum alloy and bolted to each other using O-rings. They shall contain the active and live parts of the switchgear.
- E. The rated operating pressure shall be based on the insulation level of 200kV (Rated lightning impulse withstand voltage) and the rated normal current.
- F. The switchgear shall be designed for indoor operation and each panel is set onto a steel structure with suitable cut-outs for the cables.
- G. The switchgear shall be a sealed pressure system as per IEC 62271-200 with a leakage rate of less than 0.1 % per year and free of refilling under normal service conditions.
- H. SF6 Alternative gas shall only be used for insulating.
 1. The insulation level required shall be maintained inside the gas compartments without additional insulation material.
 2. Enclosures shall have a degree of protection of IP65 and consist of corrosion-resistant aluminum alloy housings.
- I. Inside the panels, circuit-breakers shall be arranged in such a way that both the operating mechanism and the switching units can be dismantled and mounted from the front or from the rear in case of necessary revision.
 1. In a revision case all busbar operation remains uninterrupted without any restriction of the insulation level.
- J. Each closed gas compartment shall have its own pressure relief which prevents uncontrolled bursting of the housing in case of an arc fault.
 1. Pressure monitoring shall be made with contact manometers.
 2. Each busbar section shall be equipped with one contact manometer per phase

- a. One contact manometer shall be provided for all pole units of the circuit-breaker.
- 3. All contact manometer shall provide SCADA the individual high and low limit alarm for each compartment and busbar phase.
- K. Wiring shall be identified by printing on wire jacket or wire sleeves. Adhesive wire labels are not acceptable. Terminal blocks with marking strips shall be provided for all secondary and control circuits leaving the switchgear.
- L. Control circuit protection shall be provided by miniature circuit breakers or fuses.
- M. Control voltage shall be as shown on the Contract Drawings.
- N. The switchgear shall use hermetically sealed and grounded metal chambers for encapsulating all live high voltage components providing safe operations of the equipment. The switchgear shall be protected against contamination, moisture, foreign objects and it is independent from environmental conditions.

2.05 SF6 GAS ALTERNATIVE

- A. An Sulphur-hexafluoride (SF6) gas alternative shall be used for internal insulation only. Circuit interrupting shall take place in the standard vacuum circuit-breaker. Each compartment shall have its own gas supervision by contact-pressure gauges.
- B. In the unlikely case of total gas loss in a compartment the switchgear shall be able to withstand the normal operating voltage.
- C. The SF6 gas alternative shall meet all CARB requirements.

2.06 BUSBAR ARRANGEMENT

- A. Each pole shall be installed in a separate busbar housing with a separate gas pressure gauge. The insulators carrying the flat copper busbar shall be used to absorb transverse forces arising from short-circuits, allowing movement in the longitudinal direction of the busbar.

2.07 THREE-POSITION DISCONNECTOR

- A. Disconnectors shall be designed as three-position disconnectors and shall be used in combination with the circuit-breaker. The three-position disconnector shall be used for make- proof feeder grounding. The operation of the three positions CLOSED/OPEN/READY-TO- GROUND shall be carried out by means of two different rotary levers. This switch shall be fully mechanically interlocked with the circuit-breaker so that it is impossible to operate the three- position disconnector with the circuit-breaker closed, or to remove the three-position disconnector from the position READY-TO-GROUND with the circuit-breaker closed.
- B. The disconnector contacts shall be mounted in the busbar housings and the mechanical coupling shall made through an external shaft.
- C. The operating mechanism shall be arranged on the panel front. There shall be separate operating shafts provided for the two functions disconnecting

and grounding. The rotating directions for ON resp. OFF are the same for both functions.

- D. The operating mechanism of the three-position disconnecter shall be (at a minimum) equipped with the following:
1. Manual mechanism as per specification
 2. Auxiliary contacts for disconnecter 4NO +4NC
 3. Auxiliary contacts for grounding switch 2NO + 2NC
 4. Mechanical switch position indication for disconnecter and grounding switch positions
 5. Manual operation with mechanical interlock to the circuit-breaker
 6. Locking device
 7. Interlocks
- E. The combination of three-position disconnecter and circuit-breaker shall fulfil the following internal panel interlocks:
1. Operation of three-position disconnecter cannot be selected as long as the circuit-breaker is closed. The selection "operate three-position disconnecter" also blocks operation of the circuit-breaker.
 2. Selecting "disconnecter function" or "grounding switch function" only releases the operating shaft for the associated switching operation. The operating lever cannot be removed until the switching operation has been completed.
 3. "Operate three-position disconnecter" cannot be completed until the operating lever has been removed.
 4. Feeder grounding (three-position disconnecter to READY-TO-GROUND and circuit- breaker CLOSED) is secured against de-grounding. Electrical connections to the releases are interrupted by auxiliary contacts of the three-position disconnecter in GROUNDED position. Local mechanical opening of the circuit breaker can be blocked. This is made by blocking the tripping latch, which also prevents the circuit breaker from being tripped by other external effects.

2.08 CABLE CONNECTION

- A. Cable connections or bar connections shall be made from below through the cable duct or the cable basement. Cable connections shall be designed for fully insulated connections of the "inside cone type" as per EN 50181.
- B. There are cable connections available for single-core or multiple-core cables per phase with the interface types 2 and 3 or combinations of those.
- C. Bar connections shall be made with solid-insulated bars and with gas-insulated bars.

2.09 INSTRUMENT TRANSFORMERS, INSTRUMENTS AND TRANSDUCERS

- A. Instrument transformers, where shown on the Contract Drawings, shall conform to ANSI C57.13 and/or EN 50152.
- B. Potential and current transformers shall be selected with a sufficient insulation to withstand dielectric proof tests as specified by IEC 61869-3/EN 50152-3-3 for potential transformers and IEC 61869-2 for current transformers.
- C. Potential transformers shall be provided with ratios as shown on the Contract drawings. PT ratio accuracy classification shall be 0.6W minimum at rated voltage for ANSI standard burdens and appropriate for use with selected relays and instruments as shown on the Contract Drawings. Potential transformers shall be provided with primary current limiting fuses and disconnecting means with grounding provisions. The secondary fuses shall be monitored in association with the Devices 27 and 21 for interlocking security.
- D. Current transformers shall have a minimum current accuracy class of C200 for 600/1A CT ratios and below, and C400 for higher ratios. CT saturation shall be coordinated with the requirements for the connected relays. All current transformers shall be terminated at their first connection point with shorting blocks.
- E. All current transformers shall be selected to meet or exceed the short-time rms current requirements for mechanical rated current and thermal rated current as shown on the Contract Drawings.
- F. Current and potential transformer secondaries, except for utility metering transformers, shall be grounded with a copper conductor not smaller than 10 AWG and connected to a ground bus located as closely as possible to the transformer.
- G. Current Transformers
 - 1. Current transformers shall be designed as toroidal-core transformers. They shall be mounted at ground potential outside the metallic enclosure and they are not exposed to high voltages. The secondary connections shall be readily accessible.
 - a. Feeder current transformers shall always be mounted on the circuit-breaker housing and/or on the cable connection housing if required.
 - b. Busbar current transformers shall be directly mounted on the busbar housing between the feeders within the panel width if required per Contract Drawings.
- H. Voltage Transformers
 - 1. Voltage transformers shall be designed as inductive voltage transformers.
 - a. Busbar voltage metering, the voltage transformers shall be connected to the busbars directly or switchable by a three-position disconnecter.

- b. Feeder voltage metering, voltage transformers shall be either plugged directly on the cable connection or connected through a separate cable if required per Contract Drawings.

2.10 BUSBARS

- A. Busbars shall be made of flat copper with square cross-sections as per DIN and shall be designed continuously without transverse partition in the corresponding section. The individual busbar units shall be bolted together per panel. Compensators shall be provided after 10 panels to absorb thermal expansion and contraction.
- B. High-quality cast-resin parts with high tracking resistance shall be provided for busbar supports. All busbar sections shall be earthed in a make-proof manner. Manometers for gas pressure monitoring of the busbar sections are installed in the associated end wall.
 - a. Left end wall with Gas monitoring
 - b. Right end wall with Gas monitoring (only, if busbar sectioning is included)

2.11 OPERATING / GROUNDING

- A. Switchgear operation shall be made through control elements located on the panel front. The switchgear shall be operated from the panel front through the control board of a bay controller. A graphical LC display with a mimic diagram of the feeder shall show the switch positions. Important panel information (like measured values, status diagnosis, event logs etc.) will be announced on this display. The bay controller with control, protection and other digital functions shall be mounted in the door of the low-voltage compartment.
- B. Mechanical OFF operation shall be possible on the panel front at any time.
- C. Feeder grounding shall be made in a make-proof manner through the circuit breaker with the three-position disconnecter in "READY-TO-GROUND" position. The busbar shall be grounded by make-proof grounding switches for each busbar section.

2.12 CAPACITIVE VOLTAGE DETECTION SYSTEM

- A. For checking the voltage state of the pole capacitive voltage indicators shall be used. The capacitor shall be formed by a coupling electrode installed in the pole plate at the cable side of each circuit breaker. A plug-in voltage indicator or a maintenance-free integrated voltage detecting system flashes when high voltage is applied. This arrangement shall be safe-to-touch and shall be routine-tested at the factory. Safe isolation form supply is checked on an LRM (Low Resistance Measurement) test socket module.
- B. This LRM test socket module can be used with customary voltage detectors.

2.13 LOW-VOLTAGE COMPARTMENT

- A. Low-voltage compartments shall be located on the panel front above the operating mechanisms of the circuit breaker and the three-position disconnecter. The electrical connections from the primary part and

from panel to panel shall be made via flexible cable harnesses with 10-pole plug connectors.

- B. General bus wires shall be laid in a separate connection duct located at the top. Internal panel wires shall be routed in metal-enclosed wiring ducts. These shall be located on the left and on the right in the front part of the switchgear enclosure and are accessible from the front. The right-side wiring duct shall accommodate the internal panel wiring.
- C. Customer-specific control wires shall be routed to the low-voltage compartment through the left-side wiring duct. The external control wires will be introduced from below through an opening in the panel base.
- D. Inside the low-voltage compartment, secondary equipment shall be mounted on a rear mounting plate or on a DIN-rail system. Individual devices such as indicators, measuring instruments and all devices, which need visibility and access from outside, shall be integrated in the door of the low-voltage compartment. The other devices are mounted inside.

2.14 TEST AND MEASUREMENTS

- A. The equipment shall be type-tested according to the relevant standards. These type-tests shall be carried out at certified test laboratories. Partial tests shall be carried out at external authorities. Test certificates shall be supplied for the Engineer's review, approval, and record.
- B. The Engineer shall witness these routine and factory acceptance tests at an agreed date during the manufacturing period in the factory.
 - 1. 7.3 Measurement of the resistance of the Main circuit
 - 2. 7.104 Gas tightness test of gas-filled compartments
 - 3. 7.103 Pressure test of gas-filled compartments
 - 4. 7.1 Power frequency voltage test
 - 5. 7.101 Partial discharge test
 - 6. 7.2 Dielectric test of auxiliary circuits
 - 7. 7.102 Mechanical operation test
 - 8. 7.105 Test of auxiliary devices
 - 9. 7.106 Verification of wiring

2.15 SUPPLEMENTARY CONTROL SWITCHES, INDICATING LAMPS, AND FUSES

- A. Control and transfer switches shall be of the rotary, multi-position, cam operated, multi-stage type, with dust cover and silver-to-silver contacts rated 600 V, 20 A. Each circuit breaker control switch shall have a red and green target. Each switch shall be equipped with engraved plastic escutcheon or nameplate identifying its function and position. Handle styles shall be pistol grip for control and oval for transfer switches. Switches shall be GE Type SB-10, or approved equal.

- B. Indicating lamps assemblies shall be of the LED type for cool operation and long life.
- C. Medium voltage fuses shall be current-limiting type.
- D. Low voltage fuses shall be manufacturer's standard.

2.16 CONTROL WIRING FOR SWITCHGEAR, CIRCUIT BREAKERS, AND CONTROL PANELS

- A. Within the substation, switching station and paralleling station switchgear buildings, control, monitoring, instrumentation and instrument transformer wirings and termination cabinets shall be physically and functionally segregated to provide appropriate system reliability. Wiring shall be designed and installed to avoid as much as possible potential points of common failure between switchgear line-ups or between groups of switchgear panels identified by their associated bus bars. General wiring principle and basic wiring diagram identifying the segregation technique shall be submitted prior to manufacturing for approval by Caltrain.
- B. Control wiring shall be 600 V rated Type SIS tinned copper and/or fiber for the substation LAN, copper shall be minimum Class B stranded, except for wires crossing hinged joints and swinging panels which shall be flexible Class K stranded.
- C. Minimum conductor sizes shall be 14 AWG copper for connections within the same control and relay cubicle and 12 AWG for single-conductor connections between various units. Minimum conductor size for multi-conductor cables between various units shall be 14 AWG. Conductor size for current transformer wiring shall be 10 AWG minimum. Conductors within the switchgear panels shall be bundled according to manufacturer's standard technique of using manufactured, plug-in type connectors with matching screw-type terminal blocks. Conductor size within the switchgear shall be carefully selected with respect to cable ampacities and shall be no smaller than 14 AWG. Color of wires shall be as per manufacturer's standard. Wire identification markers should be ring-type (Shift sleeves), yellow with printed black letters and or numbers.
- D. All wiring between switchgear and other cubicles, panel, etc. shall be brought to accessible terminal blocks, located to permit cable entry at the top or at the bottom of the switchgear.
- E. All wiring between switchgear cubicles shall be brought to terminal blocks. Direct connections between devices located in different cubicles are not acceptable. The manufacturer shall install and connect all wiring in each shipping section. For connections between shipping sections, the manufacturer shall provide the cables connected at one end.
- F. All terminal blocks for external connection shall have screw-type terminals capable of receiving two 10 AWG solid copper wires. Twenty percent spare unassigned terminals are required for each cubicle. All terminal blocks shall be provided with marking strips for wire identification.

2.17 NAMEPLATES

- A. Nameplates shall be provided for each cubicle, relay, meter, switch, and device to identify its function and, where applicable, its position.
- B. Nameplates shall be fabricated from 1/8-inch (3.2mm) thick laminated plastic white letters on a black background. The lettering shall be accurately aligned and engraved into the white core. Nameplates shall be 1-inch X 2-1/2-inch (25 mm X 64 mm) minimum. Lettering shall be block lettering 1/4-inch (6 mm) high minimum.
- C. Nameplates shall be fastened with 2 oval head stainless steel machine screws or manufacturer's standard, non-adhesive method.
- D. Number, location and lettering of nameplates shall be as shown on the Contract Drawings or as shown on approved shop drawings.

2.18 PAINTING

- A. Prior to assembly and before shop painting, all surfaces of the switchgear enclosure shall be thoroughly cleaned of rust, oil, grease, dirt, and mill scale and painted both exterior and interior with one coat of rust-inhibiting primer.
- B. The exterior and interior of the switchgear shall be finished with manufacturer's standard indoor finish and color.

2.19 WARNING SIGNS

- A. Suitable warning signs shall be provided for each switchgear cubicle having the following description: "WARNING – HIGH VOLTAGE – KEEP – OUT". The sign shall be approximately 5 inches X 9 inches (127 mm X 230 mm) and shall be fabricated from sheet metal with white lettering on a red background. Lettering shall be approximately 1-inch (25 mm) high normal block lettering. Fasten signs with four flat head stainless steel machine screws.

PART 3 – EXECUTION

3.01 OPERATIONAL RELIABILITY

- A. The gas-tight enclosure of all live parts from to busbar down to the cable shall exclude any external influence on the primary part.
- B. The sealing technology shall guarantee that a leakage rate of less than 0.1% per year and gas compartment leading to an expected service life of at least 40 years under normal operating conditions.

3.02 MAINTENANCE

- A. The expected service life of the gas-insulated switchgear shall be 40 years:
 - 1. For circuit-breakers, according to the endurance class defined in IEC 62271-100
 - 2. For three-position disconnectors and grounding switches, according to the endurance class defined in IEC 62271-102.
- B. The design of the switchgear shall reduce the requirement for maintenance

to a very low level. Maintenance procedures will be confined to routine and preventive measures, which shall be carried out at regular intervals.

3.03 PERSONAL SAFETY

- A. Maximum personal safety shall be achieved by internal single-pole enclosure of components, arc-fault resistant design of the operating front and continuous mechanical and electrical interlocking concept.

END OF SECTION

SECTION 34 31 49

SURGE ARRESTERS

PART 1 - GENERAL

1.01 SCOPE

- A. The work of this Section consists of manufacturing, testing and delivering surge arresters for use on the 115 kV primary side and 2 x 27.5 kV secondary side of substation power transformers, 2 x 27.5 kV autotransformers, and 27.5 kV OCS and Autotransformer feeder circuits at two (2) Traction Power Substations (TPS), one (1) Switching Station (SWS), and seven (7) Paralleling Stations (PS), as indicated on the Contract Drawings.

1.02 REFERENCE STANDARDS

- A. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. C62.11 Metal Oxide Surge Arresters for AC Power Circuits (>1 kV)
 - 2. C62.22 Guide for the Application of Metal Oxide Surge Arresters for AC Systems
- B. National Electrical Manufacturer's Association (NEMA):
 - 1. LA 1 Surge Arresters

1.03 RELATED SECTIONS

Related requirements are included in, but not limited to, the following Sections:

- A. 34 31 03 - General Traction Power Requirements
- B. 34 31 13 - Basic Traction Power Materials and Methods
- C. 34 31 16 - TPF Grounding and Bonding

1.04 SUBMITTALS

- A. Provide submittals as specified in Section 34 31 03, and below:
 - 1. Manufacturer's descriptive literature, catalog data with model numbers, mounting requirements, electrical performance data, and other pertinent information to clearly indicate conformance with the Contract Document and all specified requirements.
 - 2. Manufacturer's arrangement drawings and installation instructions.
 - 3. Proposed method and instruments to be used for testing the arrester grounding system.

4. Outline drawings for each type of surge arrester including overall dimensions, sizes, weights, and mounting requirements.
5. Test reports for surge arrester ground resistance tests.

PART 2 – PRODUCTS

2.01 TYPE

- A. 115 kV surge arresters shall be of the standard station class gapless metal oxide type, suitable for installation, as shown on the Contract Drawings. Surge arresters shall be in compliance with the utility requirements.
- B. Surge arresters associated with 27.5 kV autotransformer and main power transformer secondary side shall be 45 kV rated voltage, gapless metal oxide type, Intermediate class.
- C. Surge arrester associated with 27.5 kV OCS and AT feeder gantry circuits shall be gapless metal oxide type, 39 kV rated voltage, intermediate class.
- D. Arresters shall conform to the applicable provisions of IEEE C62.11.
- E. The arresters shall be designed for use in a UBC seismic Zone 4 environment, and other operating conditions as specified in Section 34 31 16.

2.02 MOUNTING

- A. The 115 kV and 27.5 kV arresters shall be mounted on the top of the power transformers, autotransformers and 27.5 kV motorized disconnect switch supporting structures, as shown on the Contract Drawings.

2.03 RATINGS

- A. Surge arrester ratings shall be as shown in the table below:

Service	115 kV		2 x 27.5 kV SYSTEM	
	Power Transformer		Autotransformer	25 kV OCS and AT Feeder Gantry
	Primary Side	Secondary Side		
Rated Frequency, Hz	60	60	60	60
System Maximum Voltage, kV	121	29 (L-G)	29 (L-G)	29 (L-G)
Rated Voltage, kV	96	45	45	39
Maximum Continuous Operating Voltage (MCOV), Line to Ground, kV	76	36.5	36.5	31.5

Pressure Relief Device, kA, rms	60	60	40	40
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PART 3 - EXECUTION

3.01 SHIPPING

- A. The arresters shall be packaged and shipped in wooden crates suitable for outdoor storage.
- B. Packing lists, showing order numbers, shall be included in each shipment. Crating shall be designed to withstand stacking of two similar crates in either the top or bottom position without damage or deformation. Crating shall be designed for handling by forklift. Each end of the crate shall be indelibly marked with the Customer's purchase order number and item number.
- C. To prevent damage, arresters with non-ceramic composite housing shall be shipped in weather resistant, completely enclosed wooden crates. Arresters shall be individually packed within the crate such that the weight of each arrester is supported by the metal end fittings and not by the rubber weathersheds.

3.02 INSTALLATION

- A. The surge arresters shall include all necessary mounting hardware for installation on the supporting structures where shown on the approved shop drawings.
- B. Bonding cable associated with the surge arrester shall be installed with the minimum number of bends and the largest radius bends possible.
- C. Surge arresters shall be connected to separate ground rods or TPS facility ground grid.

END OF SECTION

SECTION 34 31 51

SUBSTATION AND GANTRY POST INSULATORS

PART 1 – GENERAL

1.01 GENERAL

- A. This Section includes requirements for manufacturing, testing, delivery, and installation of Substation and Gantry Post Insulators for outdoor installation.
- B. Substation and Gantry Post Insulators shall be used for the following:
 - 1. 115 kV Substation Post Insulators to support 115 kV aluminum pipe bus at high-voltage traction power substations.
 - 2. 115 kV Substation Standoff Insulators to support 115 kV cable jumpers on dead-end structures at high-voltage traction power substations.
 - 3. 46 kV Standoff Insulators to support aluminum pipe bus and wire jumpers at 25 kV feeder gantry structures.

1.02 SUBMITTALS

- A. Submit data for each type of product indicated. Include rated capacities, operating weights, and accessories. Data shall be sufficient to indicate conformance to all specified requirements.
- B. Outline drawings of each insulator type with overall dimensions, sizes and weights.
- C. Shop Drawings such as:
 - 1. Complete assembly drawings showing elevations and section views of the instrument transformer.
 - 2. Mounting plate bolt spacing and sizes.
- D. Submit characteristic curves and burdens. Submit frequency response curve shall be provided (60 Hz through 3000 Hz).
- E. Submit certified factory test reports.
- F. Submit the installation data, including mounting instructions and required clearances.
- G. Submit Maintenance Data.

1.03 QUALITY ASSURANCE

- A. Supplier Qualifications

1. The manufacturer of the insulators shall have a minimum of five years manufacturing experience manufacturing 46 kV and 115 kV post insulators.
 2. 115 kV insulators shall be proven standard products.
- B. Obtain insulators and related accessories through one source from a single manufacturer.
- C. Comply with:
1. American National Standards Institute (ANSI):
 - a. ANSI B1, Guide for Quality Control
 - b. ANSI C2, National Electrical Safety Code
 - c. ANSI C29.1, Test Methods for Electrical Power Insulators
 - d. ANSI C29.7, Wet Process-Porcelain Insulators High-Voltage Line – Post Type, including Supplement C29.7a
 - e. ANSI C29.9, Wet-Process Porcelain Insulators (Apparatus, Post Type)
 2. NFPA 70, National Electrical Code (NEC)
 3. National Electrical Contractors Association (NECA) Standards of Installation
- D. Comply with UL Standards for listed products.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

- A. Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include following:
1. Lapp
 2. Hubbell (Ohio Brass)
 3. Victor Insulators
 4. Or approved equal

2.02 115 KV POST INSULATORS

- A. Description: Bus support insulators shall be outdoor type station post insulators. The insulators shall conform to the technical requirements of ANSI C29.9.

- 1. Ratings:
 - a. Nominal voltage rating 115 kV
 - b. Maximum design voltage 121 kV
 - c. Impulse withstand voltage 550 kV
- 2. Insulators shall be the high strength type with minimum cantilever strength of 2,600 pounds.
- 3. Insulators shall be the 4-bolt type with bolt hole circle 5 inches minimum.
- 4. Insulators shall be made of dense, wet process porcelain, homogeneous and completely vitrified, with a continuous uniform standard gray glaze.
- 5. All 115 kV insulators shall be shipped completely assembled.
- 6. All insulator stack sub-bases shall be provided with adjustable means for aligning the busses. All hardware integral with the insulators shall be hot dipped galvanized or constructed of aluminum alloy of equivalent strength.
- 7. The insulators shall be treated with Sylgard High Voltage Insulator Coating or equal due to harsh atmospheric environment.

2.03 46 KV STANDOFF INSULATORS

- A. Description: 46kV insulators shall be outdoor type station post insulators and shall be suitable for vertical or horizontal mounting. The insulators shall conform to the technical requirements of ANSI C29.9.
 - 1. Ratings:
 - a. Nominal voltage rating 46 kV
 - b. Impulse withstand voltage 250 kV
 - 2. Insulators shall have minimum cantilever strength of 1,300 pounds.
 - 3. Insulators shall be the 4-bolt type with bolt hole circle 3 inches minimum.
 - 4. Insulators shall be constructed of one of the following:
 - 5. Wet process porcelain, homogeneous and completely vitrified, with a continuous uniform standard gray glaze.
 - 6. Polymer with fiber glass core.
- B. All insulators shall be shipped completely assembled. All hardware integral with the insulators shall be hot dipped galvanized or constructed of aluminum alloy of equivalent strength.

2.04 FINISHES

- A. Insulator bases shall be galvanized in accordance with the manufacturer's standard specifications, suitable for outdoor service.

2.05 IDENTIFICATION

- A. Identification markings shall be provided in accordance with ANSI standards.

2.06 FACTORY TESTS

- A. The manufacturer shall perform such tests as necessary at the factory in accordance with ANSI standards to determine that the devices meet the requirements of this specification.
- B. Factory Tests
 - 1. Factory tests shall include design and production tests identified in ANSI C29.1 performed by the supplier or a testing laboratory prior to shipment of the equipment. Unless otherwise indicated, the owner may waive the requirements for design tests upon review of test procedures, test results, and/or certified documentation of like equipment.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Install each insulator complete on the associated supporting structures in accordance with the manufacturer's instructions and as indicated on the Drawings.
- B. Use only UL listed materials.
- C. Ground the insulator supports in conformance with the design drawings.

3.02 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 - 1. Complete startup checks according to manufacturer's written instructions.
 - 2. Perform each visual and mechanical inspection and electrical test stated in an approved energization test plan.
- B. Perform installation, acceptance, and commissioning tests in accordance with approved field test procedures.

3.03 CLEANING

- A. On completion of installation, inspect the insulators. Remove paint splatters and other spots. Vacuum dirt and debris. Compressed air shall not be used to assist in cleaning. Repair exposed surfaces to match original finish and present before

and after documentation for Caltrain's review and acceptance.

END OF SECTION

SECTION 34 31 53

115 kV CIRCUIT BREAKERS

PART 1 - GENERAL

1.01 SCOPE

- A. The work of this Section consists of the designing, manufacturing, factory testing, delivering, installing, and field testing of three-pole, 115 kV, dead tank, puffer type with alternative gas to SF6, outdoor structure mounted Power Circuit Breakers for use in Traction Power Substations (TPS) as shown on the Contract Drawings.
- B. Relay and control requirements for the 115 kV Switchgear are specified in Section 34 31 39, Control and Indication Panels.
- C. TPF testing and commissioning of 115 kV Circuit Breakers is specified in Section 34 31 76.

1.02 REFERENCE STANDARDS

- A. American National Standards Institute (ANSI):
 - 1. C2 National Electrical Safety Code
 - 2. C37.04 Rating Structure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
 - 3. C37.06 Preferred Ratings and Related Required Capabilities for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current-Basis
 - 4. C37.09 Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
 - 5. C37.010 Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
 - 6. C57.13 Standard Requirements for Instrument Transformers
 - 7. Z55.1 Gray Finishes for Industrial Apparatus and Equipment
- B. American Society of Mechanical Engineers (ASME):
 - 1. ASME Boiler and Pressure Vessel Code Section VIII, Rules for Construction of Pressure Vessels, Div. 1
- C. American Society for Testing and Materials (ASTM):
 - 1. D 2472-00 Standard Specification of Sulfur Hexafluoride
- D. National Electrical Manufacturers Association (NEMA):
 - 1. EI 21.2 Instrument Transformers for Revenue Metering (125 kV BIL through 350 kV BIL)

2. ICS 4 Industrial Control and Systems: Terminal Blocks
 3. ICS 6 Industrial Control and Systems: Enclosures
 4. SG 4 AC High-Voltage Circuit Breakers
 5. 250 Enclosures for Electrical Equipment (1,000 Volts Maximum)
- E. National Fire Protection Association (NFPA):
1. 70 National Electrical Code (NEC)
 2. 101 Life Safety Code
- F. International Electrotechnical Commission (IEC):
1. 62271 High-Voltage Switchgear and Control Gear

1.03 RELATED SECTIONS

- A. 34 31 03 - General Traction Power Requirements
- B. 34 31 13 - Basic Traction Power Materials and Methods
- C. 34 31 76 - TPS Testing and Commissioning

1.04 SUBMITTALS

In addition to the submittals specified in Section 34 31 03, provide the following in accordance with Section 34 31 03:

- A. Proposal Data Required:
 1. Coil Ratings:
 - a. Trip coil amperes, each
 - b. Close coil amperes
 2. Power Requirements: Motor load – horsepower
 3. Physical Characteristics:
 - a. Total weight of breaker
 - b. Overall dimensions
 - c. Pounds of alternative SF6 gas
 - d. Bushing terminal details

4. Rating of Circuit Breaker Including:
 - a. Continuous current-carrying capability
 - b. Maximum symmetrical interrupting capability – amperes (RMS)
 - c. Three second short time current capability – amperes (RMS)
 - d. Closing and latching capability – amperes (RMS)
 - e. Rated closing time – cycles
 - f. Voltage range factor K
 - g. Number of stored CO operations
5. Product Information:
 - a. Outline drawing
 - b. Bushing drawing
 - c. Other descriptive literature
 - d. Exceptions, if any, to these Specifications
 - e. Evidence that manufacturer has supplied similar units within the past five (5) years
 - f. UBC seismic Zone 4 environment compliance details.
6. Shop Drawings and Materials List (Provided After Notice of Award):
 - a. Outline drawings, base dimensions including weight, and mounting details (for foundation purposes). Provide within the time specified in the Project Schedule.
 - b. Nameplate drawing.
 - c. Schematic and wiring diagrams (point to point type).
 - d. Bushing CT excitation and ratio correction factor curves; accuracy curves versus frequency (up to 50th harmonic).
 - e. Test results for tests specified herein, including certified test reports for metering and relaying current transformers.
 - f. Instruction manual and recommended spare parts list.
 - g. Details of terminal and ground connectors.
7. Maintenance and Instruction Manuals: One set of installation manuals (including commissioning procedures) and operating instruction manuals

shall be shipped in a pocket inside the control cabinet door and 5 copies shall be submitted to the Project Manager.

PART 2 - PRODUCTS

2.01 GENERAL CHARACTERISTICS

A. Power Circuit Breakers shall be insulated with an alternative SF6 gas that is complaint with CARB regulation, single pressure puffer type, designed for outdoor installation, 60 Hz, 3-pole, single throw with supporting framework, pneumatic, hydraulic or spring operating mechanism, and 125 VDC control.

B. Rating:

Rated Frequency	60 Hz
Nominal Voltage	115 kV
Rated Maximum Voltage	121 kV
Rated Continuous Current	2000 A
Interrupting Rating Current Symmetrical Amperes at maximum kV	40 kA
Interrupting Time (max)	3.5 cycles
BIL	550 kV
Reclosing Duty Cycle (Minimum):	OCO + 15 sec + CO

C. The circuit breakers shall be designed for use in a UBC seismic Zone 4 environment.

D. The circuit breakers shall be designed for the operating conditions specified in Section 34 31 03.

E. Breaker shall meet or exceed any requirements by the governing Utility agency.

2.02 DIELECTRIC TEST VALUES

A. Insulation Level Rated Withstand Test Voltage:

Low Frequency kV rms	260 kV dry (1 - minute)
	230 kV wet (10- second)
Impulse kV Crest	+550 kV -550 kV
Chopped Wave kV Crest	710 kV (2 microseconds)
Minimum Creepage (L-G)	70 inches (1 779 mm)

Closing and Latching Current

104 kA Peak

2.03 BUSHINGS

- A. The bushings shall be composite/polymer and gas filled. Bushings shall have electrical and mechanical characteristics suitable for 115 kV, and shall be complying with the latest ANSI standards concerning impulse and 60 Hz withstand values. Provide two (2) bushing current transformers with each bushing (Total 12).
- B. The bushings shall be furnished with four-hole, NEMA D-size pad terminals with cable/bus connectors. These pads shall be either bolted onto the bushings or threaded onto bushing studs.
- C. Bushing current transformers shall have ratios as shown on the Contract Drawings, and shall conform to ANSI C57.13, with an accuracy of C400 for relaying. Short-time ratings shall be as follows:
 - 1. Mechanical Short Time: 120 times rated secondary current.
 - 2. One-Second Thermal: 35 times rated secondary current.
 - 3. Continuous Thermal: 2 times rated secondary current.

2.04 DIMENSIONS AND WEIGHT RESTRICTIONS

- A. Due to restricted space available and foundation design, the overall breaker dimensions and weight (with SF6 gas) shall not exceed the following:
 - 1. Length: (Parallel to bus) 10'-0"
 - 2. Width: 15'-0"
 - 3. Height: 16'-6"
 - 4. Weight: 8000 lbs

2.05 CONSTRUCTION

- A. Each breaker shall be shipped with poles permanently mounted on a heavy structural base.
- B. All poles shall be factory assembled, with control wiring, installed and tested before shipment.
- C. Circuit breakers shall be primed and painted with three (3) or more finish coats to achieve a dry film thickness of at least 4 mils. Primer and paint shall not contain lead. Color shall be light gray, ANSI Z55.1, Color No. 61 or 70.

2.06 OPERATING MECHANISM

- A. The 115kV Circuit Breakers will be compliant with IEC 61850 and be addressable for remote operation and fiber communication to the substation LAN.

- B. The operating mechanism shall be of the energy storage type, spring, suitable for open/close/open operations before recharging, and electrically and mechanically trip-free and anti-pumping. The anti-pumping device shall assure that the operating mechanism makes only one closing operation with each closure of the anti-pump contact device even though the circuit- breaker trips during the closing operation and the control circuit remains closed. The stored- energy mechanism shall be capable of four (4) complete closing/opening operations at rated short-circuit current upon loss of AC power to the compressor or stored energy charging motors. If four (4) complete closing/opening operations cannot be achieved with the stored energy mechanism, then a transfer scheme to DC power shall be provided to the compressor or the stored energy charging motors, upon loss of power, in order to provide four (4) complete closing/opening operations.
- C. The mechanism shall include an automatic compressor, pump or spring charged motor for recharging, with provision for manual emergency charging of stored energy and manual emergency tripping when necessary.
- D. A mechanical position indicator shall be visible from outside, with auxiliary contacts for local and remote indication.
- E. Two (2) electrically separate trip coils shall be provided for 125 VDC trip mechanism designed so that a failure of either will not affect the other.
- F. An elapsed time meter will be provided to monitor the operating time of any compressor or pump motor.
- G. The breakers shall be equipped so that once the closing control switch has been operated, the closing sequence will not be interrupted and the breakers will make one complete closing operation, even though the control switch is released before the closing operation is complete.
- H. Operating mechanism shall have 125 VDC control system, arranged for automatic operation.
- I. Miniature circuit breakers shall be furnished for circuit breaker control, motors and heater circuits.
- J. Kirk keys and locks or an electrical system for interlocking with disconnect switches shall be provided.

2.07 GAS SYSTEM

- A. Each gas breaker shall include a gas compartment fitted with a gas-relief device.
- B. Nominal operating pressure of insulating gas shall be as low as is compatible with requirements for electrical insulation and space limitations. A curve of gas pressure versus breakdown voltage for various switchgear compartments shall be provided.
- C. Provide a local pressure alarm consisting of a red light mounted on the top of the control cabinet as far as possible from the breaker bushings. Device shall consist of a vapor tight fixture with globe and standard 60 watt incandescent lamp. Gas density/pressure devices shall have auxiliary contacts for the following functions:

1. Initiate local and remote alarms on low gas pressure (wired to SCADA system)
 2. Initiate circuit breaker automatic trip on low gas pressure (at least one percent above the minimum allowable insulating gas density/pressure)
 3. Block Circuit-Breaker Closing and Tripping
- D. Gas density/pressure shall be adjusted to provide a margin of at least 15 percent above the minimum insulating gas density/pressure at which the equipment can safely operate for an extended period.
- E. Density/pressure gauges and switches, reduction valves, and relays for gas handling shall be accessible from a convenient height.
- F. The gas system shall provide for recharging of gas from portable equipment.
- G. Receivers and tanks shall be manufactured and tested in accordance with the ASME Code Section VIII, Div. 1, Pressure Vessels.

2.08 ACCESSORIES

- A. Each circuit breaker shall be furnished with the manufacturer's standard accessories which shall include:
1. Operation counter operating the trip stroke
 2. Manual closing device
 3. Auxiliary switch with a minimum of 24 auxiliary switches, adjustable to "a" and "b" contact
 4. Two (2) grounding pads with two or four hole NEMA standard drilling
 5. Set of special tools required for installation at each substation
 6. Heaters rated 240 Volts and suitable for operation on 120 Volts, 1-phase, thermostat controlled, to prevent condensation within the mechanism housing

2.09 NAMEPLATES

- A. Durable corrosion-resistant metallic diagram nameplates shall be provided in accordance with ANSI standards. The nameplates shall also bear the purchase order number and purchase order item number.
- B. Each control device shall be provided with a suitable nameplate giving the device name plus the ANSI device number. The nameplates shall be brass, stainless steel or laminated plastic with engraved letters.
- C. Each device in the control cabinets shall be provided with an engraved laminated plastic or stainless steel nameplate.

2.10 SPARE PARTS LIST

The manufacturer shall submit a recommended spare parts list and special tools list.

2.11 SHIPPING REQUIREMENTS

Suitable crating, blocking, and supports shall be provided so equipment will withstand expected shipping and handling shocks and vibration. Equipment shall be weatherproofed for shipment. Connection openings shall be closed to prevent entrance of foreign material during shipment and storage. Equipment shall be handled and stored in conformance with manufacturer's instructions. Provide one copy of these instructions with the equipment at time of shipment. Physical inspections and tests shall be conducted as indicated in Section 34 31 76, TPF Testing and Commissioning. Verify all current transformers are short circuited prior to shipping.

PART 3 – EXECUTION

3.01 GENERAL

- A. Each outdoor type Power Circuit Breaker shall be installed on a concrete pad in accordance with manufacturer's instructions and as indicated on the Contract Drawings. The Power Circuit Breaker frames will be grounded in accordance with the substation grounding plan.

END OF SECTION

SECTION 34 31 56

115 kV DISCONNECT SWITCHES

PART 1 - GENERAL

1.01 SCOPE

- A. The work of this Section consists of the manufacturing, testing, and delivering of outdoor air break type, three pole manually and electrically operated disconnect switches for use on 115 kV utility interconnection circuits at the Traction Power Substations (TPS).
- B. All disconnect switches shall be supplied for mounting on supporting steel structures as indicated on the Contract Drawings. Switches shall be complete with all accessories, with or without manual grounding blade, and electrical operators as specified herein.
- C. Switches shall be capable of off load switching of charged lines. The maximum value of charging current shall be specified by the manufacturer.

1.02 DELIVERY

- A. All components of each switch shall be packed to permit shipment to the proposed location without repackaging. Each package shall be clearly marked to identify the item and proposed location.

1.03 REFERENCE STANDARDS

- A. American National Standards Institute (ANSI):
 - 1. C2 National Electrical Safety Code
 - 2. C29.1 Test Methods for Electrical Power Insulators
 - 3. C29.9 Wet Process Porcelain Insulators (Apparatus, Post Type)
 - 4. C37.30 IEEE Standard Requirements for High-Voltage Switches
 - 5. C37.33 Switchgear-High Voltage Air Switches-Rated Control Voltage and Their Ranges
 - 6. C37.34 IEEE Standard Test Code for High-Voltage Air Switches
 - 7. C37.35 IEEE Guide for the Application, Installation, Operation, and Maintenance of High Voltage Disconnecting and Interrupter Switches
 - 8. C437.46 American National Standard Specifications for Power Fuses and Fuse Disconnecting Switches
 - 9. C437.47 American National Standard for High Voltage Current-Limiting Type Distribution Class Fuses and Fuse

Disconnecting Switches

- B. American Society for Testing and Materials (ASTM):
 - 1. A36 Carbon Structural Steel
 - 2. A123 Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
 - 3. A153 Zinc Coating (Hot-Dip) on Iron and Steel Hardware
- C. National Electrical Manufacturers' Association (NEMA):
 - 1. ICS 4 Industrial Control and Systems: Terminal Blocks
 - 2. ICS 6 Industrial Control and Systems: Enclosures
 - 3. SG 6 Power Switching Equipment
- D. National Fire Protection Association (NFPA):
 - 1. 70 National Electrical Code (NEC)
 - 2. 101 Life Safety Code

1.04 RELATED SECTIONS

- A. 34 31 03 - General Traction Power Requirements
- B. 34 31 13 - Basic Traction Power Materials and Methods
- C. 34 31 76 - TPF Testing and Commissioning

1.05 SUBMITTALS

- A. Provide submittals as specified in Section 34 31 03, and below:
 - 1. Descriptive Data: Submit for approval descriptive data on all materials to be provided under this Section and other designated sections. Data shall be sufficient to indicate conformance to all specified requirements.
 - 2. Outline drawings for each type of disconnect switch and each shipping section with overall dimensions, sizes and weights.
 - 3. Shop drawings.
 - 4. Operating and maintenance manuals for disconnect switches. The manuals shall provide comprehensive detailed information on the approved installation, operation and use, troubleshooting, parts list, lubrication and periodic maintenance, source of replacement parts and service for the items of equipment covered.

PART 2 – PRODUCTS

2.01 GENERAL REQUIREMENTS

- A. Switches shall be group operated air break type, complete with manual operator as specified and arranged for horizontal or vertical mounting on the associated structure as shown on the Contract Drawings. Switches shall be designed, manufactured and tested in accordance with ANSI C37.30, C37.33 and C37.34, and shall be suitable for railroad traction power service. Ratings of individual units shall be as indicated on the Contract Drawings.
- B. The 115 kV disconnect switches shall be designed for use in a UBC seismic Zone 4 environment, and other operating conditions, as specified in Section 34 31 03.

2.02 DISCONNECT SWITCH CONSTRUCTION

- A. 115 kV switches shall consist of a structural steel member of adequate strength to provide rigid support, with three insulators per pole. All switches shall be specifically designed for outdoor installation. All components shall be corrosion resistant, with stainless steel springs, and galvanized structural steel channel (ASTM A36), bolts, washers, and lock washers. Galvanizing shall be in hot-dip process, in accordance with ASTM A123.
- B. All hard drawn copper alloy parts used in live parts construction of copper switches shall be 99 percent conductivity or better. All copper alloy cast parts used in live parts construction of these switches shall be of sufficient mass to insure that the casting will conduct rated current without exceeding the limits of observable temperature rise as described in Table 3 of ANSI C37.30. Contacts shall be high pressure silver-to-silver, self-cleaning by wiping action and self-aligning. Hinge and break jaw contacts shall have a wiping action which will clean the contacts when the switch is operated.
- C. Bearings shall be self-lubricating ball, roller or sleeve type, wear-resistant and maintenance-free. Bearings shall be factory adjusted. Blade operating linkage shall endure mechanical loads under normal wind without bending, breaking or cracking.
- D. Switches shall be front connected, with machined bronze terminal pads.

2.03 OPERATING MECHANISM-ELECTRICAL

- A. Motor operated disconnect switches shall be provided with a motor operating mechanism installed in a weatherproof (NEMA 4X) housing, suitable for operating at 125 VDC, as shown on the Contract Drawings. The opening time for the 115 kV disconnect switch motor operating mechanism shall be no more than 2.5 seconds. Operating cabinet shall be factory wired, with terminals for external conductors, and shall include a 100 watt fused space heater rated at 240 VAC, with adjustable thermostat, for operating on a 120 V, 60 Hz supply. Control circuitry shall permit electrical control from either a MOD control panel located in the substation control room, or remotely via the RTU of a supervisory control and data acquisition system (SCADA). Control wiring shall also include an electrical interlock to prevent operation from local control unless permitted by the associated control logic. A main circuit breaker shall be provided to isolate all power and control wiring.

- B. The motor shall be of the universal type, with brake mechanism to prevent rotation of the motor shaft and drive train when the motor is de-energized. Mechanism shall include a shaft driven limit switches assembly with a minimum of ten contacts rated 10 A, 125 VDC, field adjustable to be normally open or normally closed at either the fully open or fully closed switch position. Contactors and auxiliary relays shall be provided as required for the specified operation. All bearings shall be permanently lubricated and sealed. A decoupler shall be provided in the switch operating shaft to permit de-coupling for testing and resetting to a precise and positive setting. A swing handle socket mounted on the vertical operating pipe shall be provided to permit operation of the switch manually when de-coupled from the electrical operator.
- C. A suitable detachable handle with non-metallic grip for manual operation of the switch shall be provided in the control cabinet. Engaging of this handle for operating the switch shall disconnect the electrical control circuits. Access panel of the motor mechanism must be unlocked and swung open to permit the handle to be placed in the operating position. When de-couple from the operating shaft, switch shall be padlocked in either the open or closed position. Kirk keys and locks or an electrical system for interlocking with disconnect switches shall be provided.
- D. The motor operator shall provide independent indications for the loss of AC and DC to SCADA.

2.04 INSULATORS

- A. The insulators shall be standard or high strength porcelain as required for the specified symmetrical momentary current and actual phase spacing and shall conform to ANSI C29.9. Insulators shall be as manufactured by Locke, Lapp, or approved equal.

2.05 ARCING HORNS

- A. The designated switches shall be equipped with arcing horns to permit breaking of charging current. Arrangement shall include a stationary horn attached to the switch jaw and a movable horn attached to the blade designed to avoid arcing at the main contacts of the switch during current interruption, arc interruption being obtained by stretching out the arc. Horns shall be fabricated of the same metal as the blade material.

2.06 RATINGS

- A. The disconnect switches shall have ratings as listed in the table below:

Service	Utility and TPS HV Side
Maximum Voltage	121 kV
System Nominal Operating Voltage	115 kV
System Frequency	60 Hz

BIL Rating	550 kV
60 Hz Rated Withstand, Wet	230 kV
Continuous Current, Amps	1,200 (3-pole)
Momentary Asymmetrical Current, Maximum, kA	80 (3-pole)
Interrupting Current with Horn Gap, Amps	400
Poles	3

- B. Switches shall be capable of off load switching of charged lines. The maximum value of charging current shall be specified by the manufacturer.

2.07 DIELECTRIC TEST VALUES

- A. Insulation Level Rated Withstand Test Voltage: 121 kV
- B. Power Frequency kV (rms):
 - 1. Dry 1 minute: 280 kV
 - 2. Wet 10 seconds: 230 kV
 - 3. Impulse kV Crest: 550 kV

2.08 SPECIFIC ITEMS

- A. General: Individual switches shall conform to all applicable sections of this Specification as previously specified and, in addition, individual items as supplied shall be as outlined herein.
- B. Switches for 115 kV Circuits:
 - 1. 115 kV nominal, three-pole, group-operated, vertical-break, horizontally-mounted, horn- gap switch, manually-operated, complete with all parts for assembly and attachment.
 - 2. All high voltage switches (121 kV) shall be provided with a minimum of four (4) reversible auxiliary contacts.

PART 3 – EXECUTION

3.01 GENERAL

- A. Disconnect switches shall be installed in accordance with the manufacturer’s instructions and as shown on the approved shop drawings. Switches shall have

their operators, mechanisms, and linkages adjusted to within manufacturer's tolerances for opening and closing to eliminate binding or other maladjustment.

END OF SECTION

SECTION 34 31 59

INTERLOCKING WAYSIDE POWER CUBICLES

PART 1 – GENERAL

1.01 DESCRIPTION

- A. The work of this Section consists of furnishing, delivering, and installing complete wayside power cubicles to provide local and remote operation of OCS sectionalizing switches at interlockings.
- B. The wayside power cubicles will contain the control equipment for each switch and associated control power equipment, and shall be housed in a single outdoor, metal prefabricated equipment enclosure mounted on concrete piers. This control equipment includes a Substation SCADA RTU, Fiber Slack Enclosure, control power, battery, battery charger and 125 VDC distribution, 120/240 VAC power distribution, grounding, internal lights, MOD power and control, WPC HVAC unit, fire alarm, WPC door intrusion detection through SCADA and a standard wall pack emergency light.
- C. Each wayside power cubicle (WPC) shall be provided with an electrical utility service connection. The service supply voltage shall be 120/240 V, single-phase, 60 Hz. The Contractor is responsible for all work and costs required to obtain electric utility service for each WPC. Power may be derived from an existing signal CP power supply at the approval of Caltrain provided that calculations are provided demonstrating the existing supplies have adequate capacity. The Contractor may propose an existing service upgrade, static dissipative tile (SDT) floor, and other support systems as described in detail in this Section.
- D. An externally mounted receptacle for connecting the WPC to a portable 120/240 V generator shall be provided. This receptacle shall be connected to a manual transfer switch to permit manual switching between primary power source and a portable standby generator.

1.02 OPERATING CONDITIONS

- A. The wayside power cubicles will be located adjacent to the mainline electrified railroad and shall be designed to withstand the following operating conditions.
 - 1. The enclosure shall be designed in accordance with AISC specification to withstand live roof loading, wind loading, and seismic loading with all equipment and architectural treatments installed based on the service conditions described hereunder and the stresses caused during loading, transportation, and installation:
 - a. The enclosure shall be designed for operation within Seismic Zone 4 (UBC).
 - b. Range of annual atmospheric ambient temperature: -10° C (15° F) to 42° C (108° F).
 - c. Annual relative humidity: 5% ~ 95%.

- d. Maximum Sustained 2-minute Wind: 58 miles per hour
- e. Rainfall: Normal annual 15 to 20 inches.

1.03 REFERENCE STANDARDS

- A. American National Standards Institute (ANSI):
 - 1. B1.1 Unified Inch Screw Threads (UN and UNR Thread Form)
 - 2. B1.13M Metric Screw Threads - M Profile (R 1989)
 - 3. C2 National Electrical Safety Code
 - 4. C37.14 Low-Voltage DC Power Circuit Breakers Used in Enclosures
 - 5. C37.16 Preferred Ratings, Related Requirements and Application Recommendations for Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors
 - 6. C37.20.1 Metal Enclosed Low-Voltage Power Circuit Breaker Switchgear
 - 7. C80.1 Rigid Steel Conduit, Zinc Coated
 - 8. 27.3.4 American National Standards Institute (ANSI) Standards
 - 9. ANSI-J-STD-607-A: Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
 - 10. ANSI/ICEA S-87-640: Standard for Outside Plant Communications Cable
 - 11. ANSI/ICEA S-80-576: Communications Wire and Cable for Wiring of Premises
 - 12. ANSI/ICEA S-83-596: Standard for Fiber Optic Premises Distribution Cable
 - 13. ANSI/HFES 100: Human Factors Engineering Requirements for Visual Display Terminal (VDT) Work Stations
- B. American Society for Testing and Materials (ASTM):
 - 1. A123 Zinc (Hot-Dip Galvanized) Coatings for Iron and Steel Products
 - 2. A153 Zinc Coating (Hot-Dip) on Iron and Steel Hardware
 - 3. A167 Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
 - 4. A569 Steel, Carbon (0.15 Maximum, Percent) Hot Rolled Sheet and Strip Commercial Quality
 - 5. A575 Steel Bars, Carbon, Merchant Quality, M-Grades

6. A576 Steel Bars, Carbon, Hot-Wrought, Special Quality
 7. B3 Soft or Annealed Copper Wire
 8. B8 Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
 9. B173 Rope-Lay-Stranded Copper Conductors Having Concentric-Stranded Members, for Electrical Conductors
 10. B189 Lead-Coated and Lead-Alloy-Coated Soft Copper Wire for Electrical Purposes
 11. B633 Electrodeposited Coatings of Zinc on Iron and Steel
 12. D2802 Ozone-Resistant Ethylene-Propylene Rubber Insulation for Wire and Cable
 13. E84 Surface Burning Characteristics of Building Materials
- C. National Electrical Manufacturers Association (NEMA):
1. 250 Enclosures for Electrical Equipment (1,000 Volts Maximum)
 2. AB1 Molded Case Circuit Breakers and Molded Case Switches
 3. BU1 Busways
 4. ICS 4Terminal Blocks for Industrial Use
 5. PB1 Panelboards
 6. RN1 Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Conduit
 7. SG3 Low-Voltage Power Circuit Breakers
 8. TC2 Electrical Plastic Tubing (EPT) and Conduit (EPC-40 and EPC-80)
 9. TC3 PVC Fittings for use with Rigid PVC Conduit and Tubing
 10. VE Metallic Cable Tray Systems
 11. WC70 Standard for Nonshielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy
 12. WD1 General Requirements for Wiring Devices
- D. National Fire Protection Association (NFPA):
1. 70 National Electrical Code (NEC)

- E. Underwriters Laboratories, Inc. (UL):
 - 1. 5 Surface Metal Raceways and Fittings
 - 2. 6 Rigid Metal Conduit
 - 3. 20 General Use Snap Switches
 - 4. 67 Panelboards
 - 5. 83 Thermoplastic-Insulated Wires and Cables
 - 6. 467 Grounding and Bonding Equipment
 - 7. 489 Molded Case Circuit Breakers and Circuit Breaker Enclosures
 - 8. 506 Attachment Plugs and Receptacles
 - 9. 542 Lampholders, Starters and Starter Holders for Fluorescent Lamps
 - 10. 651 Schedule 40 and 80 Rigid PVC Conduit
 - 11. 870 Wireways, Auxiliary Gutters and Associated Fittings
 - 12. 924 Emergency Lighting and Power Equipment
 - 13. 1059 Terminal Blocks
 - 14. 8750 Safety standards for LED Lighting
 - 15. 1581 Reference Standard for Electrical Wires, Cables and Flexible Cords
- F. California Building Code, ASTM, ACI, AISC, NESC, California Green Building Standards Code and other applicable codes and standards

1.04 RELATED SECTIONS

- A. Related Sections include, but are not limited to, the following:
 - 1. 34 31 66 - 25 KV Disconnect Switches
 - 2. 34 31 26 - TPF Batteries and Accessories
 - 3. 34 31 13 - Basic Traction Power Materials and Methods
 - 4. 34 31 11 - Substation Supervisory Control and Data Acquisition (SCADA) System
 - 5. 34 31 76 - TPF Testing and Commissioning
 - 6. 34 31 89 - TPF Enclosures

1.05 SUBMITTALS

- A. Submit the following in accordance with Section 34 31 03:
1. Wayside power cubicle dimensioned outline drawings, general arrangement drawings, single line diagrams, schematic diagrams, and wiring plans, layout (plan and elevations), and external architecture.
 2. Wayside power cubicle structure design drawings including frame details, panel details, door details, ventilation details, etc.
 3. Manufacturer's catalog data, shop drawings, and product information, including model numbers or item identification, weights, ratings, etc.
 4. Manufacturer's installation instructions and recommendations.
 5. Manufacturer's operation and maintenance manual.
 6. Electrical equipment interconnection diagrams, wiring, and interconnection schedules.
 7. Design calculations including structural analysis calculations for building and seismic loadings as detailed below:
 - a. Structural calculations shall be certified by a structural engineer registered in the State of California.
 - b. Compare stress capacities/allowable stresses to applied stresses.
 - c. Include manufacturer's gauge metals cut sheets showing material properties.
 - d. Clearly define assumptions, loads, constants, and abbreviations used.
 8. Heating capacity calculations as detailed below:
 - a. Provide heating calculations for the winter season at the minimum exterior ambient temperatures and thermostat set points specified in Section 34 31 03, General Traction Power Requirements. Clearly define assumptions, loads, constants, and abbreviations used.
 - b. Neglect electrical equipment heat contribution.
 9. Air conditioning capacity calculations as detailed below:
 - a. Provide air conditioning calculations for the summer season at the maximum exterior ambient temperatures and thermostat set points specified in Section 34 31 03, General Traction Power Requirements. Clearly define assumptions, loads, constants, and abbreviations used.
 - b. Include the heat contributions of all enclosure electrical

equipment with the equipment operating at 100 percent rated continuous load.

10. Lighting layouts showing illumination levels shall be approved by Caltrain.
 11. Duplex receptacle layout shall be approved by Caltrain.
 12. Manufacturing and factory test schedule.
 13. Factory test procedures.
 14. Factory test results.
 15. Request for shipment/equipment release.
- B. One (1) copy of each document shall be submitted.
- C. Final drawings shall also be provided in electronic format (AutoCAD) at the time of shipment.

1.06 FACTORY TESTING

- A. Factory testing shall be performed on each piece of equipment to recognized standards identified within this specification, to manufacturer's recommendations, and in accordance with Section 34 31 76, TPF Testing and Commissioning.
- B. Testing of the wayside power cubicle shall be performed. Testing prior to completion of the full installation is acceptable.
- C. Where necessary input, output and proof of correct wiring of field terminals shall be performed by applying the appropriate operating voltages to each circuit in lieu of the remote equipment being made available.
- D. The Contractor shall notify Caltrain to witness the factory testing. Not less than 30 days notice shall be provided.

1.07 SHIPMENT

- A. Each wayside power cubicle shall be shipped directly to the site and shall be stored properly and protected from damage.

1.08 WARRANTY

- A. The Contractor shall provide a minimum of one (1) year full warranty on all equipment provided.

1.09 GENERAL REQUIREMENTS

- A. The WPC shall provide low voltage AC auxiliary power for anti-condensation heaters associated with motor-operated disconnect switches (MOD), SCADA RTU, as well as 125 VDC for MOD operation.

- B. The equipment housed within the WPC shall include:
1. 120/240 VAC distribution panel with main circuit breaker from a local utility electrical service
 2. 125 VDC distribution panel
 3. Battery, battery rack, and battery charger
 4. Three pole 120/240 VAC manual transfer switch
 5. Termination/SCADA interface cabinets
 6. RTU interface cabinet and provision for installation of RTU and a Remote I/O
 7. Externally mounted 120/240 V single-phase, 200 A receptacle, back box, and an indoor manual transfer switch (MTS) for emergency backup mobile generator supply
 8. Internal WPC lighting and power, WPC door intrusion detection through SCADA, and fire alarm system
 9. HVAC and thermostat controller
 10. All interior cabling, wireways, and terminations to facilitate the above equipment and purpose of the wayside power cubicle
 11. All equipment external to the wayside power cubicle enclosure will be provided and installed by others or other contract requirements
 12. Lightning Protection and Grounding Arrangement such as ground grid and room halo
 13. Fire Alarm Control, including the fire extinguisher
 14. Cable and conduit Entrance/Exit (and other protrusions) details including firestop and water/moisture protection.
- C. The building size, equipment, and general arrangement shall be substantially as indicated on the Contract Drawings. The Contractor shall propose actual equipment arrangement and specifications for approval.
- D. The Contractor shall design, size, and rate the building internal systems including lighting and power, heating and ventilation, intrusion detection.
- E. Electrical components specified in this Section shall be fully integrated with equipment in the related Sections, and work shall include all operations necessary to furnish, install, test, adjust, and put into satisfactory operation all electrical equipment and systems shown on the Contract Drawings and/or specified in the related Sections.

1.10 QUALITY ASSURANCE

- A. The work included in this Section shall be performed in strict accordance with the requirements of the Quality Control Program and in compliance with the requirements of these Specifications.

PART 2 – PRODUCTS

2.01 GENERAL

- A. Materials furnished shall be the standard products of manufacturers regularly engaged in the production of materials specified.

2.02 MOBILE BACKUP GENERATOR INTERFACE EQUIPMENT

- A. An indoor manual transfer switch and outdoor generator connection receptacle shall be installed for each wayside power cubicle as indicated on the Contract Drawings.
- B. The manual transfer switch shall be connected to the main breaker in the 120/240 V distribution panel inside the WPC. The manual transfer switch shall be padlockable and provide means to isolate the generator supply.
- C. The manual transfer switch shall be 120/240 V, three position, rated minimum 200 A, 60 Hz, manually operated, installed in an indoor type padlockable NEMA-1 enclosure, and shall have auxiliary switches for remote indication of position. One (1) set of contacts (1 NC and 1 NO) shall be provided for each switch position. The status indications shall be wired into the WPC, to the SCADA interface cabinet, ready for connection to SCADA.
- D. The “primary source” poles of the manual transfer switch shall be connected to a 120/240 V, 200A electric utility service. Utility service metering and disconnection equipment shall be mounted on the exterior of the enclosure in accordance with the utility company’s requirements.
- E. The “backup source” poles of the manual transfer switch shall be connected to an adjacent outdoor generator receptacle mounted on the WPC. The receptacle shall be rated for 120/240 V, 200 A, 3-pole, watertight and arranged for bottom plug insertion from below. Device type, Hubbell (Kellems) HBL3200RS2W, or equivalent, shall be used. The receptacle shall be mounted to a metallic watertight back box designed for use with the receptacle proposed.
- F. Connections between the devices shall be routed in GRS conduit sized by the wayside power cubicle supplier.
- G. Catalog cut sheets shall be submitted for the proposed equipment.

2.03 WPC BATTERY SYSTEM

- A. The WPC battery system shall conform to the applicable subsections of Section 34 31 26, TPF Batteries and Accessories.

2.04 WPC OUTDOOR METAL ENCLOSURE

- A. Outdoor metal enclosure shall be prefabricated, climatized, self-supporting and transportable weatherproof unit, rain-tight, NEMA-3R equivalent, suitable for installation using steel or concrete piers to be provided with each cubicle. Provisions shall be included for entry of the associated conduits. The inside and outside of the enclosure shall be protected with durable polyester powder finish, color ANSI-61 light gray.
- B. The enclosure shall be tamper resistant and shall be provided with thermostatically controlled heating and cooling.
- C. Ventilating openings shall be provided complete with filters located behind each opening to retard the entrance of dust, foreign matter, insects and rodents. All openings shall be drip proof construction.
- D. Ground bus and ground lugs shall be provided.
- E. Lighting fixtures, lighting control switch, and convenience outlets shall be provided.
- F. Doors shall have three-point latching and panic hardware and door handle shall have provisions for pad locking and/or seals as required. The door locking mechanism shall be able to be replaced with a lock at a later date. Lock type will be provided by Caltrain upon request.
- G. A heating and air-conditioning cooling system shall be provided, sized sufficiently for the wayside power cubicle and its internal equipment to ensure operation at the optimum temperature in a dust-free work environment to maintain reliability of operation.
- H. Enclosure Structures:
 - 1. The enclosure structures shall be built in a continuous modular section not requiring assembly in the field. The height and width of the individual modules shall be within legally transportable limits. The length may vary to suit the design requirements. The complete building shall be assembled, wired and bolted together at the vendor plant. The Supplier shall identify any equipment requiring to be disassembled for transport. Full instructions for re-assembly shall be provided complete with on-call field support, if necessary.
 - 2. Galvanized Steel:
 - a. Steel Sheets No. 14 Gauge or Lighter: ASTM A526, coating designation G90.
 - b. Steel Heavier Than No. 14 Gauge: ASTM A36, hot-dip galvanized after fabrication in accordance with ASTM A123 and ASTM A153, as applicable.
 - 3. All joints shall be properly sealed to prevent ingress of moisture, dampness and dust.
 - 4. The building shall have an integral floor with a perimeter steel beam and shall be capable of spanning across and being bolted down to the finished

piers and beams. Provisions shall be made for lifting and moving heavy equipment into and out of the building. Portions of the floor shall be designed for a minimum load of 250 pounds per square foot and shall be capable of supporting full operating weight of equipment when moving across the floor.

- I. WPC enclosure construction requirements shall conform to the applicable subsections of Section 34 31 89, TPF Enclosures.
- J. WPC Fire and Intrusion Detection Systems:
 - 1. The wayside power cubicle shall have a fire detection system. Whenever a detector senses a parameter value in excess of the threshold (e.g., rate-of-rise of temperature exceeding 15° F per minute); it shall signal the control panel. The control panel shall change the respective zone status to 'alarmed' while activating the panel alarm. The zone and panel status shall be communicated to the OCC using the SCADA System. The control panel shall also activate the local alarm strobe.
 - 2. The wayside power cubicle shall also have ionization smoke detectors as sensor inputs to the Fire Control Panel. Whenever a detector senses a parameter value in excess of the threshold smoke level; it shall signal the control panel and trigger an alarm in the same manner as fire detector.
 - 3. The control panel shall be programmed to trigger a panel alarm when fire or smoke is detected regardless of the panel state, i.e., armed or disarmed.
 - 4. The wayside power cubicle shall have intrusion detection as defined herein.
 - 5. Door-mounted magnetic contact at the specified locations on the Contract Drawings shall send alarm signal through SCADA when activated.
 - 6. Intrusion detection system shall be armed and disarmed by a keypad inside the building. A signal shall be sent to SCADA notifying the headend of the status of the IDS, i.e. in alarm or normal.
 - 7. The Fire Alarm system shall be tested at the factory prior to shipment for intrusion, smoke detection for correct operation and indication. Each detector shall be operated to ensure that the indicating lamp at the control panel is lit.
 - 8. The wayside power cubicle shall have HVAC with thermostat, also other required ventilation openings for batteries.

2.05 UTILITY ELECTRIC SERVICE METER PANELS

- A. If required, metering cabinets shall conform to each utility's requirements. When located outdoors, metering cabinets shall be a weatherproof unit suitable for mounting utility-furnished metering devices. The Contractor shall furnish evidence of utility approval prior to shipment to the site.

- B. The service equipment enclosures shall be rain-tight, NEMA 3R, suitable for wall or pedestal mounting as required, and fabricated of galvanized sheet steel. Provisions shall be included for entry of the associated conduits. Finish shall be light gray enamel, ANSI 61.
- C. Wiring: Panel shall be factory wired to terminal strips for terminating all wiring, including CT and PT secondary wire connections. Wire connections and terminals shall be of the solderless type of the required size copper wire. Ground bus and ground lug(s) shall be provided.
- D. Metering cabinet shall be tamper-resistant, with provisions for utility padlocking and/or seals as required.

2.06 FOUNDATIONS

The design of the foundations for all of the equipment and structural steel located at wayside power control cubicles (WPC) shall:

- A. Conform to established civil and structural engineering practices: California Building Code, ASTM, ACI, AISC, NESC, and other applicable codes and standards.
- B. Be structurally capable of withstanding the live loads and dead loads occurring during installation, operation, and maintenance and be capable of spanning field installed piers without deflection.
- C. Consider, amongst other issues, the local flood, soil, and seismic conditions at the WPC site. Refer to the Drainage chapter for establishing the floor height above the 100-year and 500-year flood elevations. Refer to the Seismic and Structures chapters for specific requirements.
- D. The design of the foundations shall ensure water drains to the site drainage system and prevent standing water at/under equipment and/or structural steel.
- E. Anchor bolts (hold-down bolts) shall be galvanized.
- F. See the Structures Specifications for additional requirements.

2.07 PROHIBITED MATERIALS AND METHODS

- A. Contractor shall ensure the following materials and methods are excluded:
 1. Extra-flexible, metallic or non-metallic, non-labeled conduit.
 2. Plastic conduit for interior electrical use.
 3. Steel Conduit shall not be used outside unless in concrete. Use Galvanized Rigid Steel (GRS) conduit outside and wet locations above grade.
 4. Aluminum wiring.

5. Incompatible Materials:
 - a. Aluminum fittings and boxes shall not be used with steel conduit.
 - b. All materials in a raceway system shall be compatible.
 - c. Dissimilar Metals: All dissimilar metals shall be properly insulated to prevent galvanic action.
 - d. When bronze and aluminum components come into contact with dissimilar metals, surfaces shall be kept from direct contact by painting the dissimilar metal with a heavy coat of a proper primer or asphalt paint.
 - e. When aluminum components come into contact with cement or lime mortar, exposed aluminum surfaces shall be painted with heavy bodied bituminous paint, water-white methacrylate lacquer, or zinc chromate.
 - f. Fasteners: All exposed fasteners shall be stainless steel.
 - g. Multi-use Suspension Systems: Piggy-back suspension systems for conduits and fixtures are prohibited. All suspensions shall be hung independently from structure, or, in limited cases, from trapeze suspension systems.
 - h. Use of wire ties to support conduit.
 - i. Use of splices to join communications or electrical wiring within duct banks and raceways.

2.08 HEATING, VENTILATION, AND AIR CONDITIONING

- A. Provide heavy duty, one piece wall-mounted, factory-assembled modular HVAC units as detailed below:
 1. The normal WPC enclosure HVAC controller set point range is expected to be between 68° F to 78° F. The maintained enclosure temperature for HVAC system design purposes shall be 72° F.
 2. Cooling and heating capacities to meet the specified requirements as per WPC thermal load calculations service.
 3. Economizer option with built-in exhaust damper to allow user-adjustable volumes of filtered exterior cooling air input under appropriate conditions.
 4. Disposable filters adequate for preventing the entry of dust. Filters shall be replaceable pleated micro glass high efficiency filters to ASHRAE Standards 52.1 and 52.2.
 5. Cabinet of minimum twenty-gauge galvanized steel with exterior finish capable of resisting a minimum 1,000-hour salt spray exposure,

per ASTM B117.

6. Quiet operation as measured from the enclosure interior and exterior.
7. Proven method of leak-proofing at the unit interface with the enclosure.
8. Install the thermostatically controlled HVAC system in accordance with the manufacturer's instructions, complete and ready for operation.
9. Digital controller with the following features:
 - a. Compressor current and dirty filter sensors.
 - b. HVAC failure alarm relay outputs that annunciate.
 - c. Alarm contact that annunciates when interior temperature exceeds 100° F.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Installation of the wayside power cubicle shall be in accordance with Section 34 31 13, Basic Traction Power Materials and Methods.
- B. Grounding:
 1. At-grade locations: wayside power cubicles (WPC) in at-grade locations shall be grounded by separately driven ground rods at opposite corners, which are to be connected to grounding pads on the enclosure.
 2. Aerial locations and in tunnels, trenches, retaining wall and retained fill structures, the WPC shall be grounded by two interconnections to a grounding plate.

END OF SECTION

SECTION 34 31 66**TPF 25 kV DISCONNECT SWITCHES****PART 1 - DESCRIPTION****1.01 SCOPE**

- A. The work of this Section consists of the manufacturing, testing, and delivering of outdoor, no- load air break type, manually and electrically operated disconnect switches within the traction power facilities including the feeder gantries. This includes, but is not limited to, mounting steelwork, hardware, locking devices, grounding and bonding systems, and necessary cable jumpers between feeder cables, switches, and the catenary system.
- B. Motor operated single-pole air switches for use on the traction power system (25 kV nominal voltage, line-to-ground, for both catenary as well as Autotransformer feeders).
- C. All disconnect switches shall be supplied for mounting on supporting steel structures as indicated on the Contract Drawings. Switches shall be complete with all accessories and manual and/or electrical operators as specified herein.
- D. The switches shall be capable of off-load switching of charged lines. The maximum value of charging current shall be specified.
- E. Double-pole air switches for use as visual disconnect and phase breaks for traction power system (69kV nominal between two poles, 25Kv line to ground) as indicated in contract drawing.

1.02 DELIVERY

- A. All components of each switch shall be packed to permit shipment to the proposed location without repackaging. Each package shall be clearly marked to identify the item and proposed location.

1.03 REFERENCE STANDARDS

- A. Disconnect switches shall be designed and manufactured in accordance with the applicable standards listed below:
 - 1. American National Standards Institute (ANSI):
 - a. C37.30 Standard Requirements for High-Voltage Switches
 - b. C37.34 Standard Test Code for High-Voltage Air Switches, Insulators and Bus Supports
 - c. C37.35 Guide for Application, Installation, Operation and Maintenance of High-Voltage Air Disconnecting and Load Interrupter Switches

- d. C37.36B Guide to Current Interruption with Horn-Gap Air Switches
 - e. C37.37 Standard loading guide for AC High-Voltage Air Switches (In Excess of 1000 volts)
 - f. C37.100 Definitions of Power Switchgear
 - g. Z55.1 Gray Finishes for Industrial Apparatus and Equipment
2. American Society for Testing and Materials (ASTM):
- a. A36 Galvanized Steel Channels
 - b. A123 Hot-Dip Galvanizing
 - c. A153A Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware – AASHTO No.: M232
 - d. B187 Copper Bus Bar, Rod and Shapes
3. Institute of Electrical and Electronics Engineers (IEEE):
- a. 1 Standard General Principles for Temperature Limits in Rating of Electrical Equipment and for Evaluation of Electrical Insulation
 - b. C37.32 High-Voltage Switches, Bus Supports and Accessories, Schedule of Preferred Ratings, Construction Guidelines and Specifications
4. National Electrical Code (NEC, NFPA 70)
5. National Electrical Manufacturers' Association (NEMA):
- a. C29.9 Wet-Process Porcelain Insulators – Apparatus, Post-Type
 - b. SG5 Power Switchgear Assemblies
 - c. SG6 Power Switching Equipment
 - d. TR214 Disconnect Switch Insulators
6. Occupational Safety and Health Administration (OSHA)
7. Underwriters' Laboratories, Inc. (UL)
8. Local codes, as applicable.

1.04 RELATED SECTIONS

- A. 34 31 16 - TPF Grounding and Bonding

- B. 34 31 86 - Feeder and Rail Return Cables
- C. 34 31 76 - TPF Testing and Commissioning

1.05 SUBMITTALS

- A. The Contractor shall prepare detailed designs for each of the required assemblies based on the information specified on the Contract Documents, including details for mounting switches, insulators, operating mechanisms and other related assemblies on the structure, including necessary catenary feeding/sectionalizing jumpers, showing details and dimensions of the parts and their relationship to each other, and describing the material composing the various parts, together with technical, mechanical and electrical characteristics.
- B. The Contractor shall include the following:
 - 1. Complete manufacturer's descriptions, catalog data, shop drawings and information including model and parts numbers.
 - 2. Manufacturer's general and detail arrangement drawings, and installation instructions.
 - 3. Operation and maintenance manual with a list of recommended spare parts.
 - 4. Manufacturer's Certificate.
- C. Submit details of tests proposed and the procedures and forms to be used during tests and inspection.
- D. Specific warranties, guarantees, spare parts list and manuals.

1.06 ACCEPTABLE MANUFACTURERS

- A. Alstom
- B. Artwell Electric
- C. S&C Electric Company
- D. Turner Switch
- E. Southern States
- F. Siemens Electric
- G. Or approved equal

PART 2 - PRODUCTS

2.01 GENERAL

- A. Materials shall comply with UL testing and product requirements.
- B. Disconnect switch insulators shall be station post type NEMA TR-214, or approved equal.
- C. The disconnect switches shall be used as a means of connection/disconnecting the catenary and negative feeders and for electrically isolating sections of the catenary at section insulator/insulated-overlap/phase-break locations. During the interim and final stage, the switches shall normally be in the position indicated on the Contract Drawings.
- D. Disconnect switches shall be for outdoor service for catenary sectionalizing and traction power feeder disconnects as specified in the Contract Drawings. The catenary disconnect switches shall be "grounding types" at locations shown on the Contract Drawings.
- E. Disconnect switches shall be assembled on galvanized steel channel bases with standard NEMA mounting holes and arranged in coordination with the supporting members necessary to attach to and support on the catenary structures.
- F. Current-carrying parts shall be of hard-drawn copper or high conductivity aluminum. Contacts shall be high pressure, silver-to-silver, self cleaning by wiping action, self aligning, and shall be capable of breaking system charging currents.
- G. High strength, high conductivity metals shall be used for all live parts. These metals shall not be subject to deterioration due to weather conditions and shall be non-ferrous.
- H. Solderless, clamp type terminal pads of a compatible design suitable for the application shall be provided.
- I. Springs, pivots, bearing and ferrous material shall not be part of a current carrying circuit.
- J. The disconnect switches shall be furnished with mounting bolts, nuts, washers, lock washers, grounding stud and all other parts and materials necessary for complete mounting of the switch and its attachment to the supporting members.
- K. Terminal connectors shall be of clamp-type hot-dip tinned bronze. Ground terminal of grounding- type disconnect switches shall be connected to the structure.
- L. The switches shall be designed and constructed to assure satisfactory operation under all weather conditions, including snow, sleet and ice, independent of lubrication. Cotter pins shall not be used to transmit stresses. All current carrying parts of the switch as well as contacts shall be designed to operate with minimum maintenance and shall maintain electrical clearance to all non live parts.

- M. Single-pole and double-pole disconnect switches shall be permanently identified using numbers, as indicated on the Contract Drawings. Identification shall meet the requirements of Section 34 31 03, Paragraph 2.3. The Contractor shall submit a sample of the identification sign for approval prior to fabrication, or installation.
- N. After installation of a switch and prior to energization of the catenary system, the Contractor shall verify correct operation of the disconnect switch installed under this Contract, and shall demonstrate such operation to the satisfaction of Caltrain.
- O. All wiring shall be provided as required. Conductor sizes, composition and insulation shall be as indicated on the Contract Drawings. All necessary additional hardware such as bushings, connectors, and all basic electrical materials needed for the installation of the equipment and accessories shall be supplied and installed by the Contractor.
- P. The installation shall conform to National Electrical Code (NEC).

2.02 DISCONNECT SWITCH CONSTRUCTION

- A. The disconnect switches shall consist of a structural steel member of adequate strength to provide rigid support, with three insulators per pole. All switches shall be specifically designed for outdoor installation. All components shall be corrosion resistant, with stainless steel springs, and galvanized structural steel channel (ASTM A36), bolts, washers, and lock washers. Galvanizing shall be in hot-dip process in accordance with ASTM A123.
- B. All hard drawn copper alloy parts used in live parts construction of copper switches shall be 99 percent conductivity, or better. High conductivity aluminum alloy may be used. All alloy cast parts used in live parts construction of these switches shall be of sufficient mass to insure that the casting will conduct rated current without exceeding the limits of observable temperature rise as described in Table 3 of ANSI C37.30. Contacts shall be high pressure silver-to-silver, self-cleaning by wiping action and self-aligning. Hinge and break jaw contacts shall have a wiping action which will clean the contacts when the switch is operated. Flexible leads or shunts at the switch hinge are not acceptable. Bearings shall be self-lubricating ball, roller or sleeve type, wear-resistant and maintenance-free. Bearings shall be factory adjusted. Blade operating linkage shall endure mechanical loads under normal wind without bending, breaking or cracking. Switches shall be front connected, with machined bronze or aluminum terminal pads.

2.03 OPERATING MECHANISM - MANUAL

- A. Each switch and operating mechanism shall be designed so as to prevent accidental or unauthorized operation and each operating mechanism shall be arranged for padlocking. Each position shall be clearly identified on a plate at the operating handle location. Identify "OPEN", and "CLOSED" positions and, where applicable, "GROUND". Should the locking mechanism include any removable parts, such parts shall be fastened by a chain in order to prevent loss.

- B. Each disconnect switch operating handle shall be provided with an outdoor-type, heavy duty, keyed padlock having a hasp diameter of ½ inch minimum. All padlocks shall be keyed alike. Two keys shall be provided for each padlock.
- C. Each switch shall be provided with a suitable manual operating mechanism mounted on the side or back of the pole at a height suitable for manual operation. The operating mechanism shall be complete and shall include all necessary shafts, interconnecting and interlocking rods, offset link, vertical operating pipe, splice and guide plates, outboard bearings and operating handles with removable extensions and locking plates. All cams, gears, cranks and other mechanism when attached to the shaft shall be keyed to the shaft. Braided copper jumpers shall be provided for grounding the operating shafts to the grounding cable.

2.04 OPERATING MECHANISM – ELECTRICAL

- A. The motor operated disconnect switches (MODs) shall be provided with a motor operating mechanism installed in a weatherproof (NEMA 3X) housing, suitable for operating at 125 Vdc, as shown on the Contract Drawings. Operating cabinet shall be factory wired, with terminals for external conductors, and shall include a 100 watt fused space heater rated at 120 Vac, with thermostat, for operating on a 120 V, 60 Hz supply. Control circuitry shall permit electrical control from either a MOD control panel located in the substation control room, or remotely via the RTU of a supervisory control and data acquisition system (SCADA). Control wiring shall also include an electrical interlock to prevent operation from local control unless permitted by the associated control logic. A main circuit breaker shall be provided to isolate all power and control wiring.
- B. The motor shall be of the universal type, with brake mechanism to prevent rotation of the motor shaft and drive train when the motor is de-energized. Mechanism shall include a shaft driven limit switches assembly with a minimum of ten contacts rated 10 A, 125 Vdc, field adjustable to be normally open or normally closed at either the fully open or fully closed switch position. Contactors and auxiliary relays shall be provided as required for the specified operation. All bearings shall be permanently lubricated and sealed. A decoupler shall be provided in the switch operating shaft to permit de-coupling for testing and resetting to a precise and positive setting. A swing handle socket mounted on the vertical operating pipe shall be provided to permit operation of the switch manually when de-coupled from the electrical operator.
- C. A suitable detachable handle for manual operation of the switch shall be provided in the control cabinet. Engaging of this handle for operating the switch shall disconnect the electrical control circuits. Access panel of the motor mechanism must be unlocked and swung open to permit the handle to be placed in the operating position. When de-coupled from the operating shaft, switch shall be padlocked in either the open or closed position. Keys and locks or an electrical system for interlocking with disconnect switches shall be provided.
- D. The control schematics shown on the design drawings are typical schematics intended to indicate functional requirements. The manufacturer shall provide all additional devices necessary to perform the functions indicated.

2.05 INSULATORS

- A. The insulators shall be standard or high strength porcelain as required for the specified symmetrical momentary current and actual phase spacing and shall conform to NEMA C29.9. Insulators shall be as manufactured by Locke, Lapp, or approved equal.

2.06 ARCING HORNS

- A. The designated switches shall be equipped with arcing horns to permit breaking of charging current. Arrangement shall include a stationary horn attached to the switch jaw and a movable horn attached to the blade designed to avoid arcing at the main contacts of the switch during current interruption, arc interruption being obtained by stretching out the arc. Horns shall be fabricated of stainless steel.

2.07 GROUNDING SWITCHES

- A. The designated air break switches shall be equipped with grounding switch assemblies applied to either the hinge or jaw end as specified. Grounding switch shall be interlocked with the main switch to prevent both switches being closed at the same time. Ground switches shall be designed, built and tested to same standards as the associated equipment, including momentary ratings and wind loading resistance.

2.08 AUXILIARY SWITCHES

- A. All disconnect switches (manual or motorized) operators shall be provided with shaft actuated auxiliary interlock switch assemblies. Each assembly shall include a minimum of four (4) field reversible voltage free contacts for remote indications of the disconnect status. Contacts shall be rated 10 amperes, 125VDC, in a weatherproof NEMA 3X housing with conduit openings for the associated control wiring.

2.09 RATINGS

Service	Feeder and Catenary Circuits	Double-Pole Circuits
Rated Voltage	46 kV	69 kV
Maximum Voltage	48.3 kV	72.5 kV
System Nominal Operating Voltage	25 kV (L-G)	55 kV (L-L)
System Frequency	60 Hz	60 Hz
BIL Rating	250 kV	350 kV

60 Hz Rated Withstand, Wet	125 kV	180 kV
60 Hz Rated Withstand, Dry	170 kV	235 kV
Continuous Current, Amps	1200	2000
Momentary Asymmetrical Current, Maximum, kA	61	61
Three Second Rating, kA	38.12	38.12
Poles	1	2

PART 3 – EXECUTION

3.01 INSTALLATION

- A. The disconnect switch assemblies and operating mechanisms shall be installed as indicated in the Contract Drawings and supplemental drawings furnished by the Contractor and approved by Caltrain while in accordance with the instructions and recommendations of the manufacturer.
- B. The disconnect switch shall be designed and installed so that the base will not be stressed unequally or distorted when bolted to its supporting members or during operation.
- C. Operating linkages and mechanisms shall be fully assembled and tested for ease of operation and proper alignment for makeup of the contacts.
- D. All insulators associated with the disconnect switch installation shall be wiped clean after the installation is complete. Disconnect switches with broken insulators will not be accepted.

END OF SECTION

SECTION 34 31 69**TPF EXTERIOR LIGHTING AND LIGHTNING PROTECTION****PART 1 – GENERAL****1.01 REQUIREMENTS**

- A. This Section includes the furnishing and installation of lightning protection and lighting fixtures, support poles and brackets, and associated control devices for a Traction Power Facilities (TPF).
- B. The lighting equipment specified herein includes pole and structure mounted outdoor floodlights, light fixtures, and controls for each type of TPF, Traction Power Substations (TPS), Switching Station (SWS), Paralleling Stations (PS), and Wayside Power Cubicles (WPC) as applicable and as shown on the Contract Drawings.
- C. At TPF locations (TPS, SWS and PS), the exterior floodlighting will provide a minimum 5 ft- candles at all equipment. At TPF buildings and WPC door entry, lighting will provide sufficient illumination at entrances, door locks, and personal access. The TPF gantries shall be fitted with lighting adequate to illuminate the equipment mounted thereon.
- D. At certain locations as indicated on the Contract Drawings, the lighting support poles will also serve as lightning protection air terminal supports.

1.02 REFERENCE STANDARDS

- A. American National Standards Institute (ANSI):
 - 1. C2 National Electrical Safety Code
 - 2. C62.41 IEEE Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits
- B. American Society for Testing and Materials (ASTM):
 - 1. A53 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated-Welded and Seamless
 - 2. A167 Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
 - 3. A276 Specification for Stainless Steel Bars and Shapes
 - 4. A325 Standard Specification for Structural Bolts, Steel, Heat-Treated, 120/105 KSI, Minimum Tensile Strength
 - 5. A385 Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip)
 - 6. A507 Specification for Steel, Sheet and Strip, Alloy, Hot-Rolled

- and Cold-Rolled, Drawing Quality
7. A575 Steel Bars, Carbon, Merchant Quality, M-Grades
 8. B26 Specification for Aluminum-Alloy Sand Castings
 9. B85 Specification for Aluminum-Alloy Die Castings
 10. B117 Standard Practice for Operating Salt Spray (Fog) Apparatus
 11. B136 Method for Measurement of Stain Resistance of Anodic Coatings on Aluminum
 12. B137 Test Method for Measurement of Coating Mass Per Unit Area of Anodically Coated Aluminum
 13. B209 Aluminum and Aluminum-Alloy Sheet and Plate
 14. B221 Aluminum and Aluminum Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
 15. B244 Test Method for Measurement of Thickness of Anodic Coating on Aluminum and of other Nonconductive Coatings on Nonmagnetic Basis Metals with Eddy-Current Instruments
 16. D635 Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position
 17. D1056 Specification for Flexible Cellular Materials # Sponge or Expanded Rubber
 18. D1400 Test Method for Nondestructive Measurement of Dry Film Thickness of Nonconductive Coatings Applied to a Nonferrous Metal Base
 19. D2240 Rubber Property – Durometer Hardness
- C. American Association of State Highway and Transportation Officials (AASHTO):
1. LTS-1 Light Pole Standard
- D. Federal Specification (FS):
1. FF-B-588D Bolt, Toggle; and Expansion Sleeve, Screw
 2. FF-S-325 Shield Expansion; Nail Expansion; and Nail, Drive Screw (Devices, Anchoring, Masonry)
 3. FF-P-395B Pin, Drive, Guided and Pin Drive, Powder Actuated (Fasteners for Power Actuated and Hand Actuated Fastening Tools)
- E. National Fire Protection Association (NFPA):
1. 70 National Electrical Code (NEC)

2. 101 Life Safety Code
3. 780 Standard for the Installation of Lightning Protection Systems

F. Porcelain Enamel Institute (PEI):

1. PEI-501 Electrostatic Porcelain Enamel Powder Application
2. PEI-502 Dipping & Flow Coating for Porcelain Enamel
3. PEI-503 Wet Spraying for Porcelain Enamel
4. PEI-801 Alloy, Design and Fab. Considerations for Porcelain Enamel Aluminum
5. PEI-802 Pretreatment of Alloys for Porcelain Enamel Aluminum
6. PEI-803 Enamel Prep, Application & Firing for Porcelain Enamel Aluminum
7. PEI-804 Quality Control Procedures for Porcelain Enamel Aluminum

G. Underwriter's Laboratories, Inc. (UL):

1. 96 Lightning Protection Components
2. 96A Installation Requirements for Lightning Protection Systems
3. 496 Safety Edison-Base Lamp Holders
4. 508 Safety Industrial Control Equipment
5. 773 Plug-In Locking Type Photo Controls for use with Area Lighting
6. 773A Non-Industrial Photoelectric Switches for Lighting Controls
7. 924 Emergency Lighting and Power Equipment
8. 8750 Safety Standard for Ligh Emitting Diode (LED)
9. 1598 Luminaires (general)

H. Lightning Protection Institute (LPI):

1. 175 Standard of Practice

1.03 RELATED SECTIONS

- A. 34 31 13 - Basic Traction Power Electrical Materials and Methods
- B. 34 31 16 - TPF Grounding and Bonding
- C. 34 31 89 - TPF Enclosures

1.04 SUBMITTALS

- A. Submit the following materials for Caltrain review and approval, in accordance with Section 34 31 03:
1. Shop Drawings: Include photometric curves.
 2. Wiring diagrams and bill of materials.
 3. Mounting details and installation instructions.
 4. Drawings showing details of lightning protection air terminal mounting and down conductor connections along with material that shows the lightning protection coverage area.
 5. Layout plans showing details of lighting levels at 3ft above ground.
 6. Documentation: Verification that each fixture is in compliance with applicable codes, regulations, reference standards and specifications for the location at which it is to be used.
 7. Manufacturer's Data: At least two weeks before start of any shop work, submit to Caltrain for approval two copies each of complete data sheets for each type of fixture.
 8. Replacement Spare Parts List.
 9. Computer based lighting analysis demonstrating specified lighting levels and illumination uniformity.

PART 2 – PRODUCTS

2.01 PRODUCTS AND MATERIALS

- A. General Requirements for Lighting Fixtures:
1. Interchangeability: Component of same type, size, rating, functional characteristics and make are to be interchangeable.
 2. Materials:
 - a. Sheet: ASTM A507, 22 gauge minimum
 - b. Bar: ASTM A575
 - c. Steel Pipe: ASTM A53, Type S
 - d. Stainless Steel:
 - i. Sheet: ASTM A167, 22 gauge, minimum
 - ii. Bar: ASTM A276, Type 316
 - iii. Finish: AISI Alloy 304, NAAMM Finish No.4, unless

otherwise shown include in reference

- e. Aluminum: Alloy as recommended by manufacturer, unless otherwise shown or specified.
 - i. Sheet and Plate: ASTM B209
 - ii. Extrusion: ASTM B221, 0.109-inch (2.76 mm) minimum thickness, unless otherwise shown
 - iii. Die Cast: ASTM B85, 0.1875-inch (4.76 mm) minimum thickness, unless otherwise shown
 - iv. Sand Cast: ASTM B26, 0.1875-inch (4.76 mm) minimum thickness, unless otherwise shown
3. Lamps:
- LED:
- i. All LED light sources shall be manufactured by Samsung, Cree, Philips-Lumileds, or Nichia.
 - ii. Finish: Inside frosted
 - iii. Base: Medium Screw or Mogul Screw
 - (1) 200 Watts and Less: Medium screw base
 - (2) Above 200 Watts: Mogul screw base
 - iv. Operating Voltage: 120 volts, 60 Hz
 - v. Rated L70 Life: 50,000 hours
4. LED Lamp Holders:
- i. In accordance with UL 496.
 - ii. Black or white thermosetting phenolic compound, glazed porcelain or neoprene base and body as shown; neoprene unit molded in one piece, weatherproof, oil-resistant, with vibration-absorbing socket construction.
 - iii. Provide mechanical self-retaining neoprene gasket for dust and moisture-proof seal between lamp and lamp holder.
 - iv. Provide vibration-proof feature to prevent lamp from loosening in lamp holder.
5. Fixture Body and Housing: Shape, size and material as required.

6. Reflector: Shape, size and material aluminum or stainless steel polished to mirror finish, minimum thickness 22 gauge.
7. Diffusers:
 - a. One-piece molded or extruded clear virgin acrylic or polycarbonate plastic having the following properties:
 - i. Interior diffusing with smooth exterior surface.
 - ii. Self-extinguishing, in accordance with ASTM D635.
 - iii. No material color change when used with lamps.
 - iv. No apparent yellowing after 500 hours exposure to fluorescent lamp source under conditions similar to those existing in the lighting fixture.
 - v. No alteration to optical properties of the fixture when finished diffuser treated with anti-static wax.
 - b. Formed so that the finished piece retains its design contours and dimensions at normal operating temperature.
 - c. Resistant to shrinking, warping, crazing, cracking, or discoloring, either in service or when stored in the manufacturer's standard shipping containers under normal conditions.
8. Globes:
 - a. Clear seamless polycarbonate or high-impact heat-resistant glass
 - b. Minimum Thickness: 0.125-inch, surface free from visible mold seam
 - c. Reduction in Strength: 10 percent maximum after five (5) years
 - d. Maximum Haze: Two percent
 - e. Minimum Light Transmittance: 88 percent
9. Lenses:
 - a. Plastic Lenses: Clear polycarbonate as shown, minimum thickness 0.06-inch (1.524 mm).
 - b. Glass Lenses: ¼-inch (6.4mm) tempered glass, laminated glass, or 1/8-inch (3.2mm) double strength clear glass as shown, capable of absorbing ultraviolet rays when used with mercury-vapor or metal-halide lamps.
 - c. Refractory Lenses: Heat-resistant annealed clear borosilicate glass, with the following additional requirements:

- i. Initial lumen distribution on horizontal plane evenly from zero to 90 degrees: 55 to 65 percent
 - ii. Minimum Efficiency: 85 percent
- 10. Gaskets:
 - a. Keyed Gaskets: One-piece extruded solid neoprene having type A durometer hardness of 30 ± 5 when tested in accordance with ASTM D2240.
 - b. Self-Retaining Gaskets:
 - i. One-piece, closed-cell sponge neoprene, soft or medium density.
 - ii. Resistant to aging, heat, ultra-violet light, water, oil, weathering and setting as determined by ASTM D1056, NEMA 12.
 - iii. Cemented to component with resilient neoprene sealing compound compatible with finish; adhesive not applied to diffuser.
 - c. Silicone gaskets equal to neoprene.
 - d. Provide gaskets for fixtures having UL labeling for wet locations and able to withstand water hose spray cleaning with 100 psi water pressure.
- 11. Hardware:
 - a. Latches, catches, release mechanism, hinges, screws, bolts, studs, nuts, rivets, washers and springs: Heavy-duty stainless steel or bronze
 - b. Latches and Catches: Captive type
 - c. Operating Hardware: Self-retaining type
- 12. Construction:
 - a. Fixture body, reflectors, wiring channels, end caps and castings formed to prevent buckling or distortion.
 - b. Minimum of two (2) wire clips provided in wiring channel to support wiring.
 - c. Seams and joints continuously welded and ground smooth.
 - d. When aluminum is in Construction with dissimilar metal, separate Construction surfaces with gasket, nonabsorptive tape, or coating to prevent corrosion.

- e. Provide air handling fixtures with combination of air supply and return path, and optional heat transfer damper.
13. Finish:
- a. Baked Enamel: Nonspecular finish consisting of six-stage hot cleaning wash, phosphate coat, prime coat, and finish coat of sprayed white or other color acrylic enamel as shown, baked at 350 degrees F for minimum of 30 minutes, with the following additional requirements:
 - i. Dry film thickness (DFT) per ASTM D1400: 1.25 mils minimum.
 - ii. Undercutting of enamel film from scored line after exposing to 10 percent salt spray for 1,500 hours, per ASTM B117: 1.70 mm (0.067 inch) maximum.
 - iii. Baked white enamel after 100 hours exposure to fadeometer: 86 percent minimum reflectance factors, no appreciable visual color change.
 - b. Porcelain Enamel: Opaque fused vitreous surface finish, 88 percent average reflectance factor, in accordance with the following standards:
 - i. On Steel: PEI - 500 Series
 - ii. On Aluminum Alloy: PEI - 800 Series
 - c. Specular Anodized Coating: 14-stage process for permanently sealed specular or semispecular finish, as shown, in accordance with patented electrolytic process, Alzak or approved equal.
 - d. Anodic Coating: AA-M22-C22-A41, minimum coating thickness 0.8 mil, coating weight 35 milligrams per square inch, hot water seal overall, tested in accordance with the following requirements:
 - i. Coating Weight: ASTM B137
 - ii. Coating Thickness: ASTM B244
 - iii. Sealing Test: ASTM B136
 - iv. Undercutting of anodic film from scored line after exposing to 10 percent salt spray for 1,500 hours, in accordance with ASTM B117: 0.067-inch (1.70mm) maximum.
 - e. Zinc Coating: ASTM A385
 - f. Shop Painting: Prepare surfaces in accordance with SSPC SP-6.

Apply coating of 8.0 mil total DFT as follows:

- i. First Coat: Inorganic zinc silicate primer applied with a dry film thickness of 2.5 to – 3 mils.
 - ii. Second Coat: High-build epoxy primer applied with a dry film thickness of 4 mils.
 - iii. Third Coat: Aliphatic polyester polyurethane applied with a dry film thickness of 1.5 to 2.5 mils.
- g. Color Anodized Finish: AA-M22-C22A42, minimum coating thickness 0.8 mil, coating weight 35 milligrams per square inch, hot water seal overall, tested in accordance with the following requirements:
- i. Coating Weight: ASTM B137
 - ii. Coating Thickness: ASTM B244
 - iii. Sealing Test: ASTM B136
- h. Electrostatic Powder Coating: Prepare surfaces by sandblast cleaning complying with SSPC Sp-10 near white blast cleaning, applying coating promptly after cleaning. Ground material should be coated. Apply coating as electrostatically- charged dry powder using electrostatic spray gun to produce DFT (dry film thickness) of 6 mils ± 2 mils. Cure by heat treatment.
14. Mark each fixture and its components in accordance with applicable reference standard.
15. Fasteners: Size and type as shown.
- a. Expansion Anchors: FS FF-S-325, Group II, Type 3, Class I, stainless steel, Type 303
 - b. Toggle Bolts: FS FF-B-588D
 - c. Powder-Actuated: FS FF-P-395B
- B. General Requirements for Mounting Poles:
- 1. Anchor Bolts: Bolts, nuts, and washers:
 - a. ASTM A325, galvanized.
 - b. Bolts hooked, unless otherwise shown or recommended by manufacturer of pole or structure being anchored.
 - c. Two (2) nuts and one (1) washer for each anchor bolt for plumbing pole or leveling structure.

2. Mounting Poles:
 - a. Steel, round section, hot-dip galvanized, as shown on the Construction Drawings and specified herein. Complete assembly of anchor bolts, pole arms, and luminaire shall be designed to withstand wind pressure (P) developed by wind speed (V) of 100 mph, in accordance with AASHTO LTS-1. Pole assemblies shall fully comply with AASHTO requirements for permissible stresses, deflection, vibration, and fatigue. Ratio of deflection to pole height under action of applicable static loading shall not exceed 1/60.
 - b. Base Assembly: Base plate, designed to withstand full bending moment of shaft and welded to shaft; complete with anchor bolts and base cover.
 - c. Handhole Size: Oval, 3-inches (76 mm) wide by 5-inches (127 mm) high, unless noted otherwise on the Construction Drawings; with minimum 12-gauge steel sheet cover plate, with radius to fit profile of pole. Provide additional internal bracing so the pole will not be weakened at the hole. Locate hole so that center is approximately 18 inches above bottom of pole, unless noted otherwise.
 - d. If Welded Construction: Longitudinally weld with continuous welds, and grind smooth.
3. Grout: see Section 03 20 00, non-shrink. Where recommended by manufacturer, prime surfaces shall be grouted.
4. Concrete Base, Including Forms and Reinforcement: see Sections 03 11 00 Concrete Forming, 03 20 00 Concrete Reinforcing, and 03 30 00 Cast-in-Place Concrete.

C. General Requirements for Control Devices:

1. Lighting Contactors:
 - a. UL 508, mechanically held, equipped with silver alloy Constructions, designed to control incandescent, tungsten, halogen, fluorescent, high-intensity discharge lamp load.
 - b. Number of Poles: As shown on plans.
 - c. Continuous Current Rating: As shown.
 - d. Line and Load Voltage: 240 or 120 Vac, single-phase, 60 Hz as shown.
 - e. Control Coil Rated 120 Vac, 60 Hz.
 - f. Control:
 - i. Heavy-duty, three-position, selector switch with

positions labeled HAND/OFF/AUTO for lights controlled by photo-electric cell.

- ii. ON-OFF switch for indoor lights.
 - iii. Remote ON/OFF controls and indication for Caltrain backoff SCADA.
- g. Enclosure: NEMA class as shown on the Construction Drawings; fabricated from steel, cleaned, degreased, primed with zinc primer and finished with light gray enamel; minimum dry film thickness, 2 mils.
2. Photoelectric Control:
- a. UL 773, designed to respond to natural daylight with 15-second inherent delay to prevent functioning due to sudden bright light such as vehicle lights or lighting and to operate in ambient temperature from 0° F to 125° F.
 - b. Adjust to turn lights ON at 2 ± 1 foot-candles, unless otherwise specified. ON to OFF ratio: One to three.
 - c. Rating: 1800 VA at 120 V, 60 Hz.
 - d. Contracts: SPDT; one NC, one NO.
 - e. Cells: hermetically sealed.
 - f. Enclosure: Weatherproof and tamperproof aluminum enclosure equipped with locking receptacles when mounted on fixture or designed for mounting on outlet box.
3. Time Switch:
- a. Seven-day, calendar-dial time switch, UL-listed, heavy-duty type suitable for controlling type of lighting fixtures.
 - b. Type: Constructions capable of switching continuous load of 20 or 40 Amps per pole at 240 V.
 - c. Providing up to four (4) automatic ON/OFF operations each day.
 - d. Removable ON/OFF trippers designed for minimum ON period of one (1) hour, and minimum two (2) hour period, between one OFF operation and next ON operation.
 - e. Provision for manual ON and OFF operation of switch by hand without disturbing weekly preset schedule.
 - f. Provision for omitting operation of switch on selected days.
 - g. Spring-driven reserve power suitable for operation of switch for

- 16 hours minimum after failure of power. On restoration of power, switch transfers to synchronous motor drive and automatically rewinds spring.
- h. Terminals designed to accommodate up to 8 mm² (8 AWG) conductor cable.
 - i. Operation at 120 V, 60 Hz and within temperature range of 0° F to plus 140° F.
 - j. Enclosure:
 - i. NEMA 1, steel, surface-mounted.
 - ii. Hinged flush front door with catches and spring-loaded door pull.
 - iii. Finish: Metallic surfaces cleaned and degreased, primed with zinc primer and finished with one coat of light gray enamel; minimum dry film thickness, 2 mils.

2.02 LIGHTING FIXTURES

- A. Lighting fixture types as described below shall be installed as shown on the Construction Drawings. Fixtures of equal characteristics and quality by other manufacturers will be considered after proper submittals have been reviewed and approved by Caltrain.
- B. Type LED Floodlights and Poles:
 - 1. General: Type LED floodlights and poles shall be installed at substations and other locations as shown on the Construction Drawings or where needed to achieve the required lighting levels and lightning protection as approved by Caltrain. Poles shall be equipped with light fixtures and fittings for LED lights; number of fixtures and wattage of lights as shown on the Construction Drawings. Lighting will be controlled by photo cell, with switching in two levels: 21.52lx (2 foot-candles) and 53.8lx (5 foot-candles).
 - 2. Lighting Fixtures: Holophane Predator PMLED lights as manufactured by Holophane Co., Inc., Newark, OH 43055, or approved equal, for outdoor installation, 240 Vac, 60 Hz, wide horizontal wide vertical beam spread, gray finish, UL Class I Div. 2 mounting, and protected starter, in die cast aluminum housing with anodized aluminum reflector and clear tempered glass lens.
 - 3. Light Poles:
 - a. Basic Requirements: Light poles shall be circular section tapered steel tube, anchor base type, hot-dip galvanized, heights as shown on the Construction Drawings, designed to conform to Paragraph 2.1B.2. Poles shall be furnished as complete units for site installation on pile type concrete bases. Each pole shall be equipped with a welded-on four-bolt anchor base and bolting set

for mounting on projecting anchor bolts, and a handhole with cover.

- C. Substation Type Lighting Fixtures for Building Mounting: Substation type lighting fixtures shall be installed on exterior walls of control buildings and switchgear enclosures at traction power substations, switching stations, and paralleling stations. The lighting fixtures shall be heavy duty outdoor type, high pressure sodium lights with cast aluminum mounting brackets, ballast, lens, reflector, and lamp as shown on the Construction Drawings.

2.03 AIR TERMINALS

- A. Provide standard air terminals of solid copper, tapered to a point; except that when mounted on aluminum surfaces, aluminum air terminals must be used. Sizes of the air terminals are to be as shown on the approved Construction Drawings.

2.04 AIR TERMINAL DOWN CONDUCTORS

- A. Provide 4/0 AWG soft-drawn copper down conductors in accordance with Section 34 31 16. These shall be used to bond the lightning terminals to the TPS, SWS and PS ground grids.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install lighting fixtures of types indicated at locations, as follows:
 1. Mount fixtures rigidly in place. Use expansion anchors and machine screws for concrete surfaces and toggle bolts for hollow concrete masonry surfaces. Use appropriate fasteners for attachment to other surfaces.
 2. Use stainless steel fasteners. Separate Construction surfaces with gasket, nonabsorptive tape or bituminous coating where metal Constructions concrete or a dissimilar metal, to prevent corrosion.
 3. Mount fixtures plumb, level and in straight lines. Install stems of suspended fixtures plumb. Group-mounted continuous rows of fluorescent fixtures should appear as one unit.
 4. Install 12-inch (305 mm) minimum length of liquid-tight flexible conduit for connection between fixture and outlet box unless otherwise shown. Use fixture wire from outlet box in branch circuit to lighting fixture and connect fixtures to branch circuit in accordance with Section 34 31 13.
 5. Clean lamps, diffusers, globes, reflectors and exposed-to-view surfaces of fixtures after aiming and adjusting has been approved.
- B. Installation of Pole-Mounted Fixtures:
 1. Form concrete bases as shown on the Construction Drawings.

2. Install mounting poles of the type specified herein. Use double nuts to erect poles plumb. Pack voids between concrete bases and pole base plates with non-shrink grout, as specified.
 3. Install conductors, leaving 3-foot (914 mm) minimum lengths of conductors for fixture connections; tape or otherwise secure in place pending final connection.
 4. Install lighting fixtures in accordance with approved shop drawings.
 5. Connect wiring using pressure connectors.
- C. Install photoelectric controls and time switches as shown or in accordance with manufacturer's instructions.
- D. Ground lighting fixtures, mounting poles, time switches, photoelectric controls and lighting Construction or enclosures in accordance with NEC and Section 34 31 16.

END OF SECTION

SECTION 34 31 76

TPF TESTING AND COMMISSIONING

PART 1 – GENERAL

1.01 SCOPE

- A. This Section covers the Contract requirements for testing and verifying the Work performed by the Contractor on all delivered Traction Power Substations, Switching Station, Paralleling Stations, Wayside Power Cubicles, equipment, materials, and accessories furnished under this Contract, prior to the HV energization and any tests requiring 115 kV or 25 kV. Factory tests shall be performed prior to shipment, and field tests shall be performed after shipment as indicated. Testing shall not commence until all design affecting the respective equipment has been reviewed by Caltrain.
- B. The Contractor shall be responsible for furnishing all test instruments and the equipment and materials necessary for performing all factory, field, and acceptance tests required.

1.02 REFERENCE STANDARDS

Unless otherwise indicated, the work covered by these Specifications shall be tested in accordance with the applicable standards of NEC, ANSI, EIA, IEEE and NEMA in effect at time of Invitation to Bid, including, but not limited to the following codes and standards:

- A. American National Standards Institute (ANSI):
 - 1. C29.1 Test Methods for Electrical Insulators
 - 2. C37.04 Rating Structure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
 - 3. C37.06 Preferred Ratings and Related Required Capabilities for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
 - 4. C37.09 Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
 - 5. C37.010 Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
 - 6. C37.011 IEEE Application Guide for Transient Recovery Voltage for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
 - 7. C37.16 Preferred Ratings, Related Requirements and Application Recommendations for Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors
 - 8. C37.17 Trip Devices for AC and General-Purpose DC Low-Voltage Power

Circuit Breakers

9. C37.20.1 Standard for Metal-Enclosed Low-Voltage Power Circuit-Breaker Switchgear
10. C37.20.2 Standard for Metal-Clad and Station-Type Cubicle Switchgear
11. C37.20.3 Standard for Metal-Enclosed Interrupter Switchgear
12. C37.34 IEEE Standard Test Code for High-Voltage Air Switches
13. C37.41 Design Tests for High Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches and Accessories
14. C37.55 Conformance Test Procedures for Metal-Clad Switchgear Assemblies
15. C37.90 Relays and Relay Systems Associated with Electric Power Apparatus
16. C37.100 Definitions for Power Switchgear
17. C39.1 Requirements for Electrical Analog Indicating Instruments
18. S82.03 Safety Standard for Electrical and Electronic Test, Measuring, Controlling and Related Equipment Electrical and Electronic Process Measurement and Control Equipment
19. C57.12.00 General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
20. C57.12.10 230 kV and Below 833/958 Through 8,333/10,417 kVA, Single-Phase, and 750/862 through 60,000/80,000/100,000 kVA, Three-Phase Without Load Tap Changing; and 3,750/4,687 through 60,000/80,000/100,000 kVA with Load Tap Changing – Safety Requirements
21. C57.12.90 Test Code for Liquid Immersed Distribution, Power, and Regulating Transformers and Guide for Short-Circuit Testing of Distribution and Power Transformers
22. C57.13 Standard Requirements for Instrument Transformers
23. C57.19.00 IEEE Standard General Requirements and Test Procedure for Outdoor Power Apparatus Bushings
24. C57.98 Guide for Transformer Impulse Tests
25. C57.113 IEEE Trial-Use Guide for Partial Discharge Measurement in Liquid-Filled Power Transformers and Shunt Reactors

B. Institute of Electrical and Electronics Engineers (IEEE):

1. 81 IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
 2. 120 Master Test Guide for Electrical Measurements in Power Circuits
 3. 450 IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications
 4. 485 IEEE Recommended Practices for Sizing Storage Batteries
 5. 693 IEEE Recommended Practices for Seismic Design of Substations
- C. National Electrical Manufacturers Association (NEMA):
1. BU 1 Busways
 2. EL21.2 Instrument Transformers for Revenue Metering
(125 kV BIL through 350 kV BIL)
 3. SG 3 Power Switching Equipment
 4. SG 4 AC High-Voltage Circuit Breakers
 5. SG 6 Power Switching Equipment
 6. WC 70 Nonshielded 0-2 kV (ICEA S-95-658)
 7. PE5 Utility Type Battery Chargers

1.03 RELATED SECTIONS

Related requirements are included in, but not limited to, the following Sections:

- A. 34 31 03 - General Traction Power Requirements
- B. 34 31 13 - Basic Traction Power Materials and Methods

1.04 SUBMITTALS

- A. Submit the following:
 1. Test Program Plan
 2. Test Procedures
 3. Installation Verification Procedures
 4. Installation Verification Reports
 5. Test Reports
 6. Test Equipment Data and Calibration Certificates

PART 2 – PRODUCTS

2.01 TEST EQUIPMENT

- A. Provide calibrated test equipment, instruments, tools, certificates, and other required items necessary to perform the tests and installation verification indicated.

2.02 REPLACEMENT MATERIALS

- A. Replace or repair equipment, parts, and materials that are rejected, damaged, lost, or consumed during performance of shop or project site tests and installation verification of the Work. Replacement materials shall be new, tested, and warranted.

PART 3 – EXECUTION

3.01 GENERAL

- A. Notification of Tests – Caltrain shall be notified not less than 14 days in advance of dates scheduled for tests and installation verification. Test procedures shall be approved by Caltrain prior to dates of scheduled tests and installation verification.
- B. Test Program Plan – Submit a plan identifying the approach to be used for accomplishing each of the required shop and field tests. The projected schedule for test and installation verification procedures, test execution, test certifications and submittal of test results shall be included.
- C. Test Procedures – Shall include as a minimum:
 - 1. Objective and scope
 - 2. Test set up
 - 3. Test equipment to be used
 - 4. Pass/fail criteria
 - 5. Samples of data sheets to be used

Test procedures shall be submitted not less than 30 days prior to the test and shall be subject to review by Caltrain. Testing may only begin after acceptance of the test procedures.

- D. Test results will be reviewed by Caltrain and accepted as submitted or additional tests may be required. If additional tests are required because test results submitted do not comply with the requirements of the specifications, the retesting is to be documented and submitted to Caltrain as part of the Work.
- E. Test Reports – Test reports shall document the results obtained and be certified by the manufacturer. Reports shall include the following:

1. Equipment tested, including model and serial numbers
 2. Title of test
 3. Objective of test and pass/fail criteria
 4. Summary and conclusions
 5. Location and date of test
 6. Test method and equipment used for test (type, model, serial number, and calibration date of every item of test equipment)
 7. Results, including calculations, curves, photographs, and other supporting data
 8. Abbreviations and references
 9. Signatures of test supervisor and witnesses
- F. Test Witnessing – Caltrain reserves the right to witness all tests including factory tests conducted elsewhere by the Contractor, its suppliers, or by an independent agency. If Caltrain determines not to witness a test or tests, test reports shall still be submitted to be Caltrain for review. Test reports shall be signed by all witnessing parties.

3.02 FACTORY AND INSTALLATION TESTS

- A. Factory tests shall include design and production tests performed by the Contractor, its supplier, or a testing agency prior to shipment of the equipment. Unless otherwise indicated, Caltrain may waive the requirements for design tests upon review of test procedures, test results, and/or certified documentation of like equipment. Tests results on like equipment or materials shall be submitted for the design tests which are to be waived.
- B. The Contractor shall test all wiring within the respective cubicles and control panels and all interconnecting wiring between cubicles before shipment. By means of high-potential, continuity, and operational tests, all wiring shall be checked for accuracy. Open- and short-circuits, ground connections, and insulation integrity. All wiring shall be given a high-potential test of 1,500 volts AC to ground for one minute. The Contractor shall also verify that the wiring is in accordance with the wiring diagrams. The wiring shall be checked complete, including inter-connections required at shipping splits. Submittal of test certifications for waiver is to be listed in the test plan when submitted.
- C. Pre-Packaged Control Building:
1. Perform water test at building joints in accordance with the weatherproofing test for outdoor metal-enclosed switchgear of ANSI C37.20.1 and C37.20.2.
 2. The HVAC system shall be tested according to manufacturer's instructions in order to verify its proper functions and settings.

D. High Voltage AC Power Cables

1. Factory Tests: As a minimum, the following production tests shall be performed:
 - a. Conductor Resistance
 - b. Insulation Resistance
 - c. High Voltage AC & DC
 - d. Shield Resistance Measurement
 - e. Partial Discharge (Corona)

E. AC and DC Control Power Systems

1. Battery – All required tests indicated in IEEE 450 shall be performed on all batteries.
2. Battery Charger – The following tests indicated in NEMA PE5 as "Design Test" shall be performed on one (1) battery charger:
 - a. Dielectric test
 - b. Circuit operation test
 - c. No-load test
 - d. Maximum output current test
3. The manufacturer's standard tests shall be performed on all battery chargers.
4. Distribution Panels – The manufacturer's standard production tests shall be performed on all AC and DC distribution panels.

F. Traction Power Transformers

1. Design Tests: Design tests shall be performed by the manufacturer on one transformer prior to series production. This transformer shall be subject to the design tests specified in Item 3 below.
2. Routine Tests: Routine tests as specified in Item 3 below shall be performed by the manufacturer on each transformer.
3. Tests specified in Table 1 shall be performed in accordance with ANSI C57.12.90 unless otherwise specified in this Specification Section.

TABLE 1: ROUTINE AND DESIGN TESTS OF TP TRANSFORMERS

TESTS	Routine	Design
Resistance Measurements	X	
Ratio (Note 1)	X	
Polarity and Phase Relation	X	
No-Load Losses and Excitation Current	X	
Impedance Voltage and Load Loss (Note 2)	X	
Temperature Rise (Note 3)		X
Dielectric Tests:		
Low Frequency (Note 4)	X	
Lightning Impulse (Note 5)	X	
RIV (Partial Discharge)		X
Insulation Power Factor		X
Insulation Resistance		X
Audible Sound Level (Note 6)		X
Short-Circuit Capability		Note 7
Mechanical:		
Lifting and Moving Devices		X
Pressure		X
Leak	X	
Load Tap Changer (Note 8)	X	

Note 1: Ratio test shall be performed on all tap positions of the load tap changer.

Note 2: Short circuit impedance and reactance measurements shall be performed on the nominal tap position and on the extreme tap positions of the load tap changer.

Note 3: Temperature rise test shall be performed in accordance with the procedure of the ANSI C57.12.90 and the requirements of Section 34 31 33, Paragraph 1.4 (G).

Note 4: Partial discharge measurement shall be performed during the induced voltage test to demonstrate that there is no damaging corona.

Note 5: If the load tap changer is located at the center point of the primary winding, the manufacturer shall ensure that the load tap changer will be subject to the full wave impulse voltage. The appropriate test procedure shall be submitted for approval. Impulse tests shall be performed with the LTC on nominal and extreme positions.

Note 6: Sound level shall not exceed 80 dBA. The load tap changer shall be on the tap position on which the highest audible sound level is produced.

Note 7: In accordance with Section 34 31 33, Paragraph 2.3, short circuit test are required on one unit.

Note 8: Routine tests shall be performed on the load tap changer when completely assembled on the transformer. Routine test shall be performed in accordance with relevant standards.

4. Installation Tests – The following tests shall be performed after installation of each traction power transformers:
 - a. Insulation test between windings, all windings to ground, and core to ground using 2,500 VDC megohmmeter. For site acceptance testing the insulation resistance testing between the core and the ground can be performed at 1,000 VDC or per the manufacturer's recommended voltage.
 - b. Routine/Functional tests of protective devices.
 - c. Tap changer test with turn ratio test on all taps for proper tap setting.
 - d. Oil sample tests, and
 - e. Busbar tests.

G. Auto Transformers

1. Design Tests: Design tests shall be performed by the manufacturer on one autotransformer prior to series production. This autotransformer shall be subject to the design tests specified in Paragraph 3 below.
2. Routine Tests: Routine tests as specified in Paragraph 3 below shall be performed by manufacturer on each autotransformer.
3. Tests specified in Table 2 shall be performed in accordance with ANSI C57.12.90 unless otherwise specified in this Specification Section.

TABLE 2: ROUTINE AND DESIGN TESTS OF AUTOTRANSFORMERS

TESTS	Routine	Design
Resistance Measurements	X	
Ratio	X	
Polarity and Phase Relation	X	
No-Load Losses and Excitation Current	X	

Impedance Voltage and Load Loss	X	
Temperature Rise (Note 1)		X
Dielectric Tests:		
Low Frequency (Note 2)	X	
Lightning Impulse		X
RIV (Partial Discharge)		X
Insulation Power Factor		X
Insulation Resistance		X
Audible Sound Level (Note 3)		X
Short-Circuit Capability (Note 4)		X
Mechanical:		
Lifting and Moving Devices		X
Pressure		X
Leak	X	

Note 1: Temperature rise test shall be performed in accordance with the procedure of ANSI C57.12.90 and the requirements of Section 34 31 36, Paragraph 1.5 (F).

Note 2: Partial discharge measurement shall be performed during the induced voltage test to demonstrate that there is no damaging corona.

Note 3: Sound level shall not exceed 70 dBA.

Note 4: In accordance with Section 34 31 36, Paragraph 2.3, short-circuit tests are required on one unit.

H. Control and Indication Panels:

1. Relays:

- a. Design Tests: Design tests shall be, or shall have been, performed on one relay of each type and rating in accordance with ANSI C37.90.
- b. Production Tests: Production tests shall be performed on all relays in accordance with ANSI C37.90.
- c. Functional tests of all devices by secondary injection (simulating input and output).

2. Meters:

- a. Design Tests: Design tests shall be, or shall have been, performed on one meter of each type and rating in accordance with ANSI C39.1.
- b. Production Tests: Production tests shall be performed on all

meters in accordance with ANSI C39.1.

- c. Functional tests of all devices by secondary injection (simulating input and output).
3. Annunciator Panels:
- a. Design Tests: Design tests shall be, or shall have been, performed on one annunciator panel of each type with all accessories in place in accordance with ANSI C37.20.1, ANSI C37.20.2 & ANSI C37.20.3.
 - b. Production Tests: By means of insulation resistance, continuity, and operation tests all annunciator panels, with all accessories in place, shall be production tested for proper operation, accuracy, short circuits, and open circuits, in accordance with ANSI C37.20.1, ANSI C37.20.2 & ANSI C37.20.3.
4. Lighting System:
- a. In-service Test Plan
 - b. Test lighting circuits for continuity and operation.
 - c. Test fixtures and equipment enclosures for continuity of grounding system.
 - d. Aim and adjust fixtures to provide desired distribution pattern.
 - e. Test time switches, control devices and contactors for connection in accordance with wiring diagram.
 - f. Check tightness of cable connections of time switches, lighting contactors, photoelectric controls and limit switches.
 - g. Test operations of circuits, control devices, and contactors.
5. Upon installation the following features shall be tested and certified for each traction power substation, switching station and paralleling station:
- a. Fire Detection System
 - b. Intrusion Alarm System

I. Instrument Transformers:

- 1. The instrument transformers shall undergo all routine tests identified in ANSI C57.13, including but not limited to:
 - a. Applied voltage test for primary and secondary windings.
 - b. Induced voltage test for secondary winding.

- c. VT accuracy tests on ratio correction factor and phase angle to confirm 0.15 percent performance at 100 percent voltage on each tap at burdens "O" and "Y".
 - d. Polarity check.
 - e. The test standard and ANSI burdens shall be rated and certified by the National Institute of Standards and Technology for accuracy testing of 0.15 percent production units.
2. In addition to the ANSI standard tests for new equipment designs, the following tests shall also be performed on each unit:
- a. Insulation power factor (dissipation factor) test to confirm that the insulation power factor of the transformer is equal to or less than 0.5 percent.
 - b. Partial discharge test shall be performed on each unit to confirm that the unit is partial discharge-free at a minimum of 135 percent of operating line to ground voltage. During the PD test, the unit shall be raised to minimum prestressed level of 200 percent of line to ground voltage.
 - c. Vacuum leak test down to 80 microns to ensure integrity of welded joints and gaskets.
- J. Pre-Packaged 2 x 25 kV Switchgear:
- 1. Design Tests – The following tests shall be performed on an ac circuit breaker and switchgear assembly:
 - a. All applicable tests identified as Design Tests in IEC 62271-1, 100 & 200 Series
 - 2. Production Tests – The following tests shall be performed on all ac circuit breakers and all switchgear assemblies:
 - a. All applicable tests identified as Production Tests in ANSI C37.09 and NEMA SG 4 on the circuit breakers.
 - b. All applicable tests identified as Production Tests in ANSI C37.20.1, ANSI C37.20.2 and ANSI C37.20.3 on the switchgear assemblies. Design tests in IEC 62271-1, 100 & 200 Series.
 - 3. Installation Tests – The following tests shall be performed after installation of all AC switchgear assemblies in each traction power substation, switching station and paralleling station switchgear building:
 - a. Continuity and insulation of all buses and wiring.
 - b. Insulation to ground tests on the buses with circuit breakers closed.

- c. Electrical operation – all circuit functional tests to be carried out (simulating operation of other devices as necessary).
- K. 115 kV Circuit Breakers:
- 1. Factory Tests: Factory tests shall be performed as specified in ANSI C37.09 and certifications provided. In addition, the following factory tests shall be performed on the assembled circuit breakers, and on individual components as required:
 - a. Pressure Tests: Each part which may be subjected to pressure in service shall be pressure tested at twice the specified service pressure.
 - b. Leakage Tests: Leakage tests shall ensure that the leakage rate will not exceed one percent, per year.
 - c. Internal Discharge Tests: Measurement of the corona inception and extinction level at refilling pressure shall be made and recorded.
 - d. Power Frequency Test: Each assembly shall be subjected to power-frequency voltage withstand tests to verify the proper installation of the conductors and insulators.
 - e. Low frequency dielectric tests and all other standard production tests on each circuit breaker.
 - f. Complete wiring and control circuit test and check for verification of all circuits are operational of each circuit breaker, including all circuit breaker interlocks.
 - 2. Production Tests: The following production tests shall be performed on an assembled circuit breaker:
 - a. Impulse tests on one (1) circuit breaker.
 - b. Heating test on one (1) circuit breaker.
 - c. Interrupting current test on one (1) circuit breaker.
- L. Manually and Electrically Operated Disconnecting Switches:
- 1. Design Tests - The following tests shall be performed on one manually operated and one electrically operated disconnecting switch:
 - a. Dielectric tests.
 - b. Short-time current tests.
 - c. Temperature-rise test.
 - 2. Production Tests – The following tests shall be performed on all

manually and electrically operated disconnecting switches:

- a. Operation of all components.
- b. Power frequency dielectric withstands.
- c. Electric resistance of current path.

3.03 PROJECT SITE INSTALLATION VERIFICATION AND ACCEPTANCE TESTS

- A. Field installation of equipment and materials shall be subjected to installation verification inspection and tests on completion of the Work, which shall include the following:
 - 1. Traction power substation, switching station, paralleling station and WPC equipment:
 - a. Verify, by visual inspection, that reassembled equipment, components, bus, and accessories are correctly installed and labeled in accordance with approved shop drawings, and are free from damage.
 - b. Perform mechanical checks on the physical integrity of all equipment furnished under this contract. These tests shall include, but not be limited to operation of all devices, interlocks, doors, access panels, etc., to demonstrate proper operation and fit.
 - c. Perform insulation resistance test on indoor AC switchgear main bus, outdoor circuit breakers, traction power transformers and autotransformers using a 2,500 VDC megaohmmeter.
 - d. Perform continuity check and dielectric tests on field installed interconnecting wiring and bus.
 - e. Perform calibration, functional, and operating tests of equipment, devices, and circuits in accordance with manufacturers' instructions.
 - f. Verify that settings of protective relays and devices are in accordance with proposed settings as approved by Caltrain.
 - g. Verify that manually and electrically operated AC disconnecting switches are correctly installed in accordance with manufacturer's instructions and approved shop drawings.
 - h. Perform dielectric tests on main current carrying parts and insulation resistance tests on control circuits of AC disconnect switches.
 - i. Perform functional and operating tests in accordance with manufacturer's instructions of AC disconnect switches.

- j. Perform installation/field tests for the transformers mentioned in Section 3.2 F and G above.
- 2. Grounding Systems:
 - a. Verify that grounding system at each traction power substation, switching station, paralleling station, and WPC are installed in accordance with the Construction Drawings.
 - b. Verify continuity of ground connections to ground grid and to isolated ground rods using an ohmmeter.
 - c. Test each grounding system using the fall-of-potential method to measure the total resistance to ground of the system. Total resistance at each traction power substation, switching station, paralleling station, and WPC shall not exceed the indicated values on the Construction Drawings.
 - 3. Wire and Cables:
 - a. Verify continuity of control wiring and power cabling from terminal to terminal and verify circuit connections and identification in accordance with approved shop drawings.
 - b. Measure insulation resistance of field installed control wiring and power cabling, using a megaohmmeter.
- B. Functional Tests:
- 1. General:
 - a. Functional tests shall be conducted on each traction power substation, switching station, paralleling station, and WPC delivered as part of the contract.
 - b. Contractor shall assume full responsibility for performing required tests and for any loss or damage to the provided equipment as a result of the tests. Replace and retest equipment and materials found to be defective or in noncompliance with the Specifications.
 - c. Circuits shall be end-to-end tested within the facility to prove full functionality, indication, control and metering to the traction power facility/WPC interface points. As far as possible alarms and indications shall be operated from the relevant protective devices. Checking for correct SCADA indication and control shall also be verified as far as practically possible.
 - d. A report shall document the results obtained from the integrated system tests. Report format shall be similar to that specified for equipment shop tests.
 - 2. Relays, Meters, and Instrument Transformers – All relays, meters, and

instrument transformers shall be checked for accuracy, performance, operation, proper setting, and calibration, as per ANSI C37.90, ANSI C37.90.1 and ANSI C57.13 and the relay coordination study performed by the Contractor.

- a. Relay Checking – Relay checking, setting, and calibration shall be performed separately from the overall inspection and testing.
 - b. Test Current – Test current shall be injected into the current circuits at the current transformer terminals to ensure protective relays operate properly by tripping their respective breakers and are polarized correctly, and to ensure that instruments read correctly and that meters are calibrated.
 - c. Checking Instruments and Telemetry Transducers – Instruments and telemetry transducers shall be checked for accuracy at quarter, half, and full- scale points.
 - d. Indicating Setting and Date – After relays have been set, a small white card stating the setting and data shall be placed within the relay case.
 - e. Provide calibration stickers.
3. Local Annunciator Panels – The following tests shall be performed in accordance with the control schematics and wiring diagrams:
 - a. Each device shall be subjected to the respective manufacturers' standard production tests.
 - b. By means of insulation resistance, 100 percent point-to-point continuity, and operation tests, each local annunciator panel shall be checked for proper operation.
 4. Supervisory Control Interface Terminal Cabinets – All terminal blocks shall be subjected to the manufacturers' standard tests.
 5. Fire Detection System – After the smoke sensing fire detection system is completely installed, it shall be tested for continuity and correct operation in accordance with NFPA 72.
 6. Programmable Logic Controller (PLC) and all associated hardware and software components.
 7. Interlocking tests shall be performed for tie breakers, phase breaks, and breaker interlocks. Provide conditions and documentation for any temporary jumpers to complete local functional testing.

3.04 SPECIAL TESTS

- A. In addition to the specified tests, special tests may be called for at the discretion of Caltrain, on equipment provided under the Contract. Special tests

shall be performed to verify compliance of the equipment and components with the Specifications. The cost of such special tests required by Caltrain on any equipment or component that is proven to comply with the Specifications will be at the expense of Caltrain. The cost of special tests on any equipment or component that is proven not to comply with the Specifications shall be at no expense to Caltrain.

- B. Provide support for SCADA or End to End testing to the communication commissioning team.

END OF SECTION

SECTION 34 31 86

FEEDER AND RAIL RETURN CABLES

PART 1 - GENERAL

1.01 SCOPE

- A. This Section includes the furnishing, installation and testing of cables, splices, terminations, and other materials associated with the 27.5 kV OCS and 27.5 kV Autotransformer feeders, and rail return cables as shown on the Contract Drawings and specified herein.

1.02 RELATED SECTIONS

Related requirements are included in, but not limited to, the following Sections:

- A. 34 31 03 - General Traction Power Requirements
- B. 34 31 13 - Basic Traction Power Materials and Methods
- C. 34 31 23 - Underground Duct Banks
- D. 34 31 76 - TPF Testing and Commissioning

1.03 REFERENCES

- A. All cable furnished under this Section shall be in accordance with the latest applicable standards of the IEEE, ANSI, NFPA, NEMA, ICEA, AEIC, and UL with regard to material, design, construction, and testing. The standards applicable shall include, but not be limited to, the following:
 - 1. Association of Edison Illuminating Companies (AEIC):
 - a. CS8 Specification for Extruded Dielectric Shielded Power Cables Rated 5 through 46 kV
 - b. CS9 Specification for Extruded Insulation Power Cables and Their Accessories Rated Above 46 kV though 345 kV
 - 2. American Society for Testing and Materials (ASTM):
 - a. B1 Hard Drawn Copper Wire
 - b. B2 Medium-Hard Drawn Copper Wire
 - c. B3 Standard Specification for Soft or Annealed Copper Wire
 - d. B8 Standard Specification for Concentric-Lay Stranded Copper Conductor Hard, Medium-Hard, or Soft
 - e. B33 Standard Specification for Tinned Soft or Annealed

- Copper Wire for Electrical Purposes
 - f. B189 Lead Coated and Lead Alloy Coated Soft Copper Wire for Electrical Purposes
 - g. B496 Standard Specifications for Compact Round Concentric-Lay Copper Conductor
 - h. D1373 Medium-Voltage Rubber Insulating Tape
 - i. D2802 Ozone-Resistant Ethylene Propylene Rubber Insulation for Wire and Cable
 - j. D3005 Low Temperature Resistant Vinyl Chloride Plastic Pressure Sensitive Electrical Insulating Tape
3. Institute of Electrical and Electronics Engineers (IEEE):
- a. 48 Standard Test Procedures and Requirements for High-voltage Alternating Current Cable Terminators
 - b. 82 IEEE Standard Test Procedure for Impulse Voltage Tests on Insulated Conductors
 - c. 141 IEEE Recommended Practice for Electric Power Distribution for Industrial Plants
 - d. 400 IEEE Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems
 - e. 404 Standard for Cable Joints for Use with Extruded Dielectric Cable Rated 5,000 Volts through 46,000 Volts
 - f. 532 IEEE Guide for Selecting and Testing Jackets for Underground Cables
 - g. 576 IEEE Recommended Practice for Installation, Termination, and Testing of Insulated Power Cable as Used in Industrial and Commercial Applications
 - h. 837 Standard for Qualifying Permanent Connections Used in Substation Grounding
 - i. 1210 Standard Tests for Determining Compatibility of Cable-Pulling Lubricants with Wire and Cable
 - j. 1202 Flame Testing of Cables for Use in Cable Tray in Industrial and Commercial Occupancies
 - k. 1235 IEEE Guide for the Properties of Identifiable Jackets for Underground Power Cables and Ducts
4. National Electrical Manufacturers Association (NEMA):

- a. WC 26 Bi-national Wire and Cable Packaging Standard
 - b. WC 70 Standard for Nonshielded Power Cables Rated 2,000 Volts or Less for the Distribution of Electrical Energy (ICEA S-95-658)
 - c. WC 71 Standard for Nonshielded Cables Rated 2,001-5,000 Volts for Use in the Distribution of Electrical Energy (ICEA S-96-659)
 - d. WC 74 5-46 kV Shielded Power Cable for Use in the Transmission & Distribution of Electric Energy (ICEA S-93-639)
5. National Fire Protection Association (NFPA):
- a. 70 National Electrical Code (NEC)
6. Underwriters Laboratories (UL):
- a. 44 Thermoset-Insulated Wires and Cables
 - b. 83 Thermoplastic Insulated Wires and Cables
 - c. 510 Insulating Tape
 - d. 1072 Medium-Voltage (Type MV) Solid-Dielectric Cables
 - e. 1581 Reference Standards for Electrical Wires, Cables and Flexible Cords
7. Federal Specifications (FS):
- a. HH-I-553 Insulation Tape, Electrical (Rubber, Natural and Synthetic)

1.04 QUALITY ASSURANCE

- A. Cable Manufacturers' Qualification: Not less than fifteen (15) years of demonstrable experience in the production of the specified products.
- B. Workmanship shall conform to the best modern practices in the manufacturing of a rugged, durable, and safe product for use in a public transportation system. Materials used shall be new and of the highest commercial grade as specified.
- C. The Insulated Cable shall be manufactured and tested under the control of a Quality Assurance system that conforms to the requirements of ISO 9000.
- D. The Quality Assurance system shall demonstrate conformance to the above criteria by having passed yearly quality audits conducted by outside independent organizations.

1.05 SUBMITTALS

The Contractor shall submit the following for review and approval of Caltrain at various stages of planning, manufacturing, and installation of cable and wire as requested:

- A. Descriptive literature, catalog data, and other pertinent information for cable and splices sufficient to clearly demonstrate compliance with the Construction Documents. Product shall consist of manufacturer's standard catalog cuts, descriptive literature and diagrams, in 8½ X 11-inch format, and in sufficient detail so as to clearly indicate compliance with all specified requirements and standards. Submit catalog cuts for the following as a minimum:
 - 1. Wires and cables for each type and size.
 - 2. Splice kit materials and installation procedures.
- B. Cable pulling plan showing cable feed and pulling winch locations, cable lengths, and calculated pulling tensions for each cable pull over 200 feet in length, or with a total of 180° or more of conduit bends.
- C. Proposed cable lubricants and associated lubricating devices.
- D. Proposed cable pulling equipment including cable grips, pulling rope, tension meters, swivels, and cable pullers (winches).
- E. Qualifications of all cable splicers proposed to be utilized for splicing work.
- F. As-built lengths of all cable installed under this Contract.
- G. Manufacturer's Certification: Manufacturer shall submit signed certification confirming that they comply with the qualifications requirements and shall provide evidence of experience upon request.
- H. Product Certification: Signed by manufacturer certifying that products comply with the specified specification requirements.
- I. Report of Field Tests: Certified copies of field tests.
- J. 24-inch long samples of the final assembled cables for First Article Inspection prior to release.
- K. Submit certified shop test reports for wires and cables.
- L. Submit field test results for wires and cables, including megger readings with the method used.

PART 2 - PRODUCTS

2.01 GENERAL

- A. The cable shall be suitable for use in wet and dry locations in underground duct systems and aerial applications. The cable shall be rated no less than 90° C for

normal operation, 130° C for emergency overload condition and 250° C for short circuit conditions. Emergency overload operation may occur for periods up to 100 hours per year and with as many as five (5) such 100- hour periods within the lifetime of the cable.

- B. Water-based, gel-type, high-performance cable-pulling lubricants shall be utilized in accordance with cable manufacturer recommendations. Minimum cable pulling lubricant requirements shall include a UL Listing and a non-combustible residue.

2.02 27.5 KV FEEDER CABLE

- A. Electrical Ratings:
 - 1. Single-conductor cable for the 27.5 kV nominal overhead contact system and negative feeder cables shall be rated for no less than 46 kV class line-to-line voltage rating basis described in NEMA WC 74.
- B. Conductor:
 - 1. Copper conductor, annealed, uncoated and Class B stranded, per ASTM B-8 for compressed round stranded, and ASTM B496 for compact round stranding.
 - 2. Conductor sizes shall be as shown on the Contract Drawings.
- C. Conductor Screen:
 - 1. The strands shall be completely shielded with a layer of semi-conducting extruded ethylene propylene rubber material compatible with the insulation. The compound shall have a maximum volume resistivity of 1000 ohm-meters at 105° C and a minimum elongation of 100 percent after an air oven test at 136° C for 168 hours. The strand shielding shall be in intimate contact with the strands and shall be completely free- stripping from the strands.
- D. Insulation:
 - 1. The insulation shall consist of thermosetting Ethylene Propylene Rubber (EPR) which will meet the requirements of the referenced AEIC and NEMA specifications with the additional requirements listed below. The ethylene content of the elastomer used in the insulation compound shall not exceed 72 percent by weight nor shall the insulation compound contain any polyethylene. The insulation shall be compounded and extruded in a closed system to insure maximum cleanliness.
 - 2. The insulation shall be circular in cross-section, and so centered that the minimum wall thickness shall be not less than 90 percent of the average thickness specified.
 - 3. 46 kV class cables: Insulation thickness shall be in accordance with NEMA WC 74 Table 4-1 for a 133 percent insulation level (between 550 and 610 mils).

E. Insulation Screen:

1. The insulation shall be completely shielded with a layer of extruded semi-conducting ethylene propylene rubber compound. The compound shall have a maximum volume resistivity of 500 ohm-meters at 90° C and a minimum elongation of 100 percent after an air oven test at 136° C for 168 hours. It shall be in intimate contact with the insulation and shall be stripped with four to twenty-four pounds of tension per 1/2-inch wide strips at room temperature. The legend "SEMI-CONDUCTING SHIELDING, REMOVE BEFORE SPLICING OR TERMINATING" shall be printed in white indelible non-conducting ink along its entire surface.

F. Metallic Shield:

1. The installation screen shall be shielded with a 5-mil tin-coated copper tape helically applied with a minimum overlap of not less than 20 percent. A longitudinal corrugated copper shield of equal or higher thickness will also be acceptable.

G. Jacket:

1. Black extruded flame retardant polyvinyl chloride jacket and sun resistant.
2. Jacket and jacket thickness shall be in accordance with NEMA WC 74 and AEIC CS8 for 46 kV class cables, and AEIC CS9 for 69 kV class cables.

2.03 RAIL RETURN CABLE

A. Electrical Ratings:

1. Single-conductor cable for rail return purposes shall be 2.0 kV class, unshielded, in accordance with NEMA WC 70, UL-44.

B. Conductor:

1. Copper conductor, annealed, uncoated and Class B stranded per ASTM B496 for compact round stranding.
2. Conductor sizes shall be as shown on the Contract Drawings.

C. Insulation:

1. Thermosetting Ethylene Propylene Rubber (EPR). Insulation thickness shall comply with NEMA WC 70 requirements.

D. Jacket:

1. Black Thermoset CPE and sun resistant.
2. Jacket and jacket thickness shall be in accordance with NEMA WC 70.

2.04 CABLE IDENTIFICATION AND LABELING

- A. The following information shall be printed on jacket, using contrasting indelible color ink, at intervals per NEMA WC 70, WC 71 and WC 74 as applicable:
1. The words: "Property of Caltrain"
 2. Manufacturer's name and plant, and year of manufacture
 3. Conductor size and material
 4. Voltage rating
 5. Insulation type and thickness (mils)
 6. Jacket type and thickness (mils)
 7. Percent insulation level
 8. UL designations (where applicable)
 9. Other appropriate conductor information
- B. Color-Coding for Power Conductors:
1. Insulation or covering of wires and cables shall be factory color-coded by the use of colored compounds or coatings. The color-code shall be followed consistently throughout the performance of the work.
 2. Upon written request of Contractor, Caltrain may permit the use of other methods of color coding, including the following methods in lieu of the wire or cable manufacturer's color coding, when limited quantities of wire and cable are involved, for sizes No. 8 AWG and larger. Method used shall conform to NEC, and be approved by Caltrain.
 - a. For dry locations only, spiral application of 3/4-inch wide, colored pressure sensitive plastic tape, half lapped for a distance of not less than six (6) inches may be used. To prevent unwinding, the last two wraps of tape shall be applied with no tension.
 - b. For wet or dry locations, application of three, 3/16-inch wide, colored, fungus- inert, self-extinguishing, self-locking, nylon cable ties spaced three (3) inches apart may be used. The ties shall be snugly applied with a special tool or pliers, and any excess removed.
 - c. Each wire and cable shall be color-coded at all terminal points, manholes, boxes, or other similar enclosures.
 - d. Color markings shall be applied so as not to obliterate the manufacturer's identification markings.

- C. Cable Tags:
 1. Stainless steel metal tags, No. 28 gauge and 3/4-inch wide, embossed with letters and numbers 5/16-inch high, with No. 14 AWG copper or nylon, weather-resistant cable ties, or stainless steel cable ties.
 2. In accordance with Section 34 31 13, Basic Traction Power Materials and Methods.

2.05 SPLICING, TERMINATING, AND ARC-PROOFING MATERIALS

- A. Splicing and terminating shall be as specified in this Section. Details of special splicing and terminating shall be as shown on the Plans or in accordance with manufacturer's recommendations. Any splicing or terminating methods other than those specified below, for which the components are in accordance with the requirements of this Section, shall be submitted for approval.
- B. Cable splices shall have documented equal-or-better electrical and mechanical characteristics than the cable being spliced. All splicing, terminating, and arc-proofing materials shall be compatible so that no one material will adversely affect the physical or electrical properties of any other or of the wire or cable itself.
- C. Splice materials shall be furnished in kit form with detailed instructions included. All materials for making splices and terminations shall be specifically designed for use with the type of wire or cable, insulation, and the operating conditions of the specific application.
- D. Splices shall be made only in manholes or in handholes, and with the approval of Caltrain.
- E. Splicing shall only be performed by qualified personnel approved by Caltrain.
- F. Cable termination fittings and lugs shall be compatible with the feeder cable and the switchgear, disconnect switch, or impedance bond to which the terminations are being made.
- G. Connectors: Subject to compliance with requirements of this Section, provide connectors of the following types:
 1. Solder-less, uninsulated, high-conductivity, corrosion-resistant, compression connectors conforming to UL 467 and IEEE 837.
 2. Insulated, indenter-type compression butt connectors.
 3. Insulated, integral self-locking flexible shell, expandable spring connectors.
 4. Uninsulated, indenter-type compression pigtail connectors.
 5. Welded-type connectors.
- H. Terminals: Subject to compliance with requirements of this Section, provide terminals of the following types:

1. Solder-less, uninsulated, high-conductivity, corrosion-resistant, compression terminals conforming to UL 467 and IEEE 837.
 2. Insulated, compression terminals.
 3. Solder-less, high-conductivity, corrosion-resistant, hex screw-type, bolted terminals.
 4. Welded-type terminals.
 5. Medium-Voltage Cable Terminators:
 - a. Shall consist of a factory-engineered kit and copper connector specifically designed for the terminating of the associated shielded cable in an outdoor location. Terminator shall be rated 46 kV, with an ac withstand one minute- voltage of 120 kV. Kit shall meet IEEE 48, Class 1 requirements, and be capable of passing the appropriate test sequence of IEEE 404. Kits shall provide for the grounding of the cable shield without the use of special construction.
 - b. Shall consist of heat-shrinkable stress control and outer non-tracking insulation tubing and outer skirts. Terminals shall be all copper, of high-conductivity, corrosion-resistant type, conforming to UL 467. Terminating kits shall be Raychem, or approved equal, and connectors shall be Burndy, or approved equal.
- I. Shrinkable Tubing: Subject to compliance with requirements of this Section, provide shrinkable tubing of the following types:
1. Either irradiated modified polyvinyl chloride or irradiated modified polyolefin heat shrinkable tubing;
 2. Cold shrinkable tubing.
- J. Tapes and Sealers:
1. Vinyl Tapes: Flame retardant, cold and weather-resistant, 3/4-inch or 1-1/2-inches wide, as required, and conforming to UL 510 and ASTM D3005.
 - a. For interior, dry locations, provide seven mils, conforming to ASTM D 3005 (Type 1); Scotch (3M) No. 33, or approved equal.
 - b. For exterior or damp and wet locations, provide 8.5 mils, conforming to ASTM D3005 (Type II); Scotch (3M) No. 88, or approved equal.
 2. Rubber Tapes: Ethylene propylene rubber based, 30 mil splicing tape, rated for 130°C operation; 3/4-inch and wider (1, 1-1/2, 2-inches) as shown on the Plans or approved by Caltrain, conforming to ASTM D1373 and FS HH-I-553 (Grade A); Scotch (3M) No. 130°C, or

- approved equal.
3. Insulating Putty: Rubber based 125 mil, 130°C rated, anti-tracking, self-fusing tape; one- inch wide; Scotch (3M) No. 70, or approved equal.
 4. Silicone Rubber Tapes: Inorganic silicone rubber, 12 mil, 130°C rated, anti-tracking, self-fusing tape; one-inch wide; Scotch (3M) No. 70, or approved equal.
 5. Sealer: Liquid-applied, fast-drying sealant; Scotch (3M) Scotchkote, or approved equal.
- K. Resin Filled Splices:
1. Epoxy Molded Type: Two-piece, snap-together molded bodies, sized for wire or cable, with two-part low velocity polyurethane insulating and sealing compound, using crimp- type wire connector; Scotch (3M) No. 87-A1, 87-A2 or 87-A3 compound, or approved equal.
 2. Re-Enterable Type: Transparent, molded bodies clamped with stainless steel strain relief bar and shield continuity connectors, sized for wire or cable, with loosely woven polyester spacer web and jelly-like urethane formulation for permanent re-entry capability; Scotch (3M) No. 78-R1 through 78-R5, with No. 2114 compound, or approved equal.
- L. Special splicing materials and methods shall be as shown on the Plans.
- M. For cable connections to GIS switchgear refer to Section 34 31 47 2.8.

PART 3 - EXECUTION

3.01 CABLE SHIPPING, STORAGE, AND HANDLING

- A. Cable shall be packaged in accordance with NEMA WC 26 and the requirements stated herein. Protective reel coverings shall be Level 3 or greater in accordance with NEMA WC 26.
- B. Insulated Cable for this design package shall be furnished in accordance with the Plans and with the following requirements. The Contractor is responsible for cable shipment, storage, and security.
 1. All traction power cable for this contract shall be shipped freight on board (FOB) site to Contractor's designated storage area - unless cable is part or spare or surplus materials. Cable shall be shipped on reels with protective covering, including wooden lags, commensurate with the weight of the loaded reel.
 2. A watertight seal shall be applied to each end of the cable to prevent moisture ingress during shipment or outdoor storage. The Contractor shall provide factory-applied caps to wire and cable sizes No. 4/0 AWG and larger unless otherwise shown on the Plans. End seals shall be heat-shrink, irradiated, modified polyolefin, and shall be sized for

individual wires and cables.

3. A durable, weatherproof label shall be securely attached to the outside of both flanges of each reel. Each label shall indicate the following:
 - a. Purchase order number
 - b. Name and address of manufacturer
 - c. Reel number
 - d. Total length of cable on reel
 - e. Description of cable
 - f. Tare and total weight of reel and rolling direction

- C. The Contractor shall ensure that single conductor wire or cable sizes No. 4/0 AWG and larger that are to be installed in the same raceway are paralleled by the cable manufacturer before shipment. Cable assembly overall diameter shall be kept to a minimum.

3.02 PREPARATION

- A. Prior to pulling wires and cables, clean raceway systems of all foreign matter and perform all operations necessary so as not to cause damage to wires and cables while pulling.
- B. Prior to pulling wires and cables into underground conduit systems, place a feeding tube approved by Caltrain at the entrance of such systems.

3.03 INSTALLATION REQUIREMENTS

- A. Double-braided cable pulling rope shall be used for all cable pulls; the use of steel cable for cable pulling is not permitted.
- B. Keep wires and cable dry at all times. Cable ends shall be properly sealed before being pulled into ducts. Cable ends shall not be left with insulation exposed after cutting unless splicing is to be performed immediately. Before splicing or terminating wires and cables, make a thorough inspection to determine that water has not entered the wires and cables or that the wires and cables have not been damaged.
- C. Strip all nails from outside edges of reel heads before pulling of cable. Conveniently locate reels for feeding cable into the duct without excessive bending or possible injury to cable by abrasion. Reels shall be jacked to clear ground level or obstructions by at least six (6) inches before pulling of cable.
- D. Pre-lubricate the ducts utilizing pumps, "front-end packs", and duct swabs where required to fully lubricate the entire length of duct in front of the advance of the cable. Continuously apply pulling lubricant to the cable itself at the duct entrance during the pull. Use adequate lubrication when installing cables in conduits or raceways. Any pulling compounds shall be compatible with the finish of the wires and cables furnished.

- E. Attach pulling ropes to cables with approved grips and swivels to prevent twisting of cable during pulling. The use of break-away swivels is not permitted.
- F. Pull cable into ducts and conduits under moderate tension. Manufacturers' recommended maximum pulling tension and minimum bending radius shall not be exceeded. Pulling tension shall be continuously monitored by an approved measuring device (tensiometer) equipped with a chart or digital recorder. Copies of the pulling tension chart recordings shall be provided to Caltrain for each cable pull.
- G. Station sufficient personnel between the reel and the duct entrance during pulling operations to inspect, control and direct the passage of the cable. Utilize split nylon tube-type duct shields and cable-feeding tubes to prevent chafing of the duct entrance and the cable.
- H. Do not permit cable to chafe on the ground, ballast, manhole edges, or any sharp surfaces. Provide timbers and flexible cable-pulling tubes to guide and protect the cable where necessary.
- I. Cables shall be arranged and neatly racked along the manhole walls. Provide sufficient bends and freedom of horizontal motion to accommodate normal cable thermal expansion and contraction. "Straight through" cable installations, without the additional bends and racking noted above, will not be permitted.
- J. Identification of Wires and Cables:
 - 1. Each wire and cable shall be identified by its circuit in all cabinets, boxes, manholes, wireways and other enclosures and access locations, and at all terminal points.
 - 2. The circuit designations shall be as shown on the Plans. Tags shall be attached to wires and cables in such a manner as to be readily visible.
 - 3. All traction power conductors shall be identified (tagged) in each manhole, handhole, and at each termination identifying the circuit or feeder.
 - 4. Wires and cables that are arc-proofed shall also be identified outside the applied arc proofing.

3.04 CABLE WARRANTY

- A. The Contractor shall replace any length of cable installed by the Contractor which fails during normal use within one year of Contract substantial completion, provided immediate written notice of such failure is given to the Contractor with all reasonable opportunity provided thereto to inspect such failure.
- B. The date of placing into service shall be interpreted as the date on which operating voltage is first continuously applied to the completed cable installation.

3.05 INSPECTION AND TESTING

- A. Inspection: Caltrain reserves the right to witness the manufacture, testing, and packaging of all conductors. The Contractor shall notify Caltrain not less than ten (10) days in advance of manufacturing and testing operations.
- B. Testing: The standard dielectric-withstand tests shall be performed on each reel of cable prior to shipment. A certified copy of the test report for each reel of cable shall be furnished to Caltrain prior to shipment. A copy of the test report shall also be packed with each reel. Test requirements shall be in accordance with NEMA WC-70, WC-71 and WC-74 as applicable.
- C. Submit samples not less than twenty-four (24) inches in length, with five (5) copies of the notarized certified test reports of each type and size of wire and cable to be furnished for First Article Inspection prior to release.

3.06 SHOP TESTS

- A. For quantities as shown on the Plans, regular dielectric-withstand and insulation resistance in water tests for wires and cables shall be performed in accordance with the referenced standards.
- B. Flame tests for wires and cables shall be performed in accordance with vertical tray flame test of UL 1581 F. Cable sizes larger than 1/0 AWG shall meet the vertical tray flame test requirements of IEEE 1202.
- C. The test results shall be certified for each reel/coil/box of wire or cable.
- D. Factory inspection and witnessing of tests by Caltrain may be required for all wires and cables furnished under this Contract. Caltrain reserves the right to require additional testing, or to waive factory inspection or witnessing of tests. The Contractor shall notify Caltrain fourteen (14) days in advance of the scheduling of such factory tests.

3.07 FACTORY CABLE TESTS (FULL LENGTH)

- A. Tests conducted at the factory shall include, but not be limited to, the following standard tests per NEMA WC 70, WC 71 and WC 74, as applicable, for the entire completed cable:
 - 1. Insulation Resistance Tests: performed in accordance with the requirements of the applicable referenced standards.
 - 2. Shield Resistance: measured and recorded from end to end on the completed cable.
 - 3. Corona Test: Each reel of completed shielded power cable shall comply with the maximum partial discharge in pico-coulombs. The partial discharge test shall be performed in accordance with the procedures of AEIC CS8 and CS9 and an X-Y recording graph will be furnished showing the corona test results.
 - 4. Water Block Test: A water penetration production test for filled strand

cable construction shall be performed on each master length of insulated conductor.

5. Flame Test: Flame Test shall be performed in accordance with the referenced standards.

3.08 FIELD TESTS

- A. Inspect wires and cables at terminations and pull boxes for physical damage and proper connection.
- B. Verify continuity of each branch circuit conductor.
- C. All feeder and rail return cables shall be Hi-pot tested to NETA and the test report shall be submitted for approval. Furnish Caltrain with a copy of the megger readings together with an outline of the method used. If, in the opinion of Caltrain, any reading is lower than that required by applicable codes, promptly replace the materials involved, at Contractor's expense, and retest.
- D. Cables shall be subjected to Acceptance Tests as specified below to ascertain that the dielectric strength of the cable insulation has not been impaired during installation, that the splices and terminations are properly made and to confirm the integrity of the cable system prior to energization. These shall include continuity tests and insulation resistance tests performed after the cable installation.
- E. Acceptance Tests: After installation of the entire length of cable, the Contractor shall perform the tests listed below on each cable in accordance with the Acceptance Testing Specifications of the National Electrical Testing Association (NETA). To preclude damage to equipment and devices, the tests shall be conducted before the cable is terminated at electrical equipment. If terminations have already been made, cables shall be disconnected from the equipment for testing and shall be reconnected after completion of tests.
 1. Dielectric Test:
 - a. This test shall be performed to ensure that the cable insulation has not been impaired during installation.
 2. Continuity Test:
 - a. This test shall be performed to prove the continuity of the conductor.
 3. Insulation Resistance Test:
 - a. This test shall be performed to determine the cable insulation resistance to ground.
 - b. Megger test voltage shall be applied between the conductor and ground and shall be held until the reading reaches a constant value for five (5) minutes. Insulation resistance values obtained by the megger tests shall not be less than two

megaohms at 1,000 V. Contractor shall bring to the attention of Caltrain the results of similar tests having unequal readings with the variations of twenty-five (25) percent or more.

- c. For each test, the Contractor shall record the temperature, humidity and duration of the test.

F. Defective Cables:

1. Cable conduits shall be sealed after testing and final connection of cables. Any cable installed under this Contract found defective during the testing shall be replaced with new cable at the expense of the Contractor.

END OF SECTION

SECTION 34 31 89

TPF ENCLOSURES

PART 1 – GENERAL

1.01 SCOPE

- A. This Section specifies design, fabrication, testing and installation of the enclosures for prefabricated-type switchgear and control houses at Traction Power Substations, Switching Station, Paralleling Stations, or Wayside Power Cubicles (WPC). This work includes enclosure lighting, HVAC, stairs for elevated enclosures and other interior and exterior furnishings as indicated on the Contract Drawings and specified herein.
- B. The Battery area shall contain the 125 VDC batteries and racks, exhaust fan, battery disconnect switch and other items of material as specified in Section 34 31 26 and as indicated on the Contract Drawings.
- C. The enclosures for the TPS's, PS's and SWS shall be provided with a Fire Detection and Suppression System in accordance with Division 28 Specifications.
- D. Testing of enclosures is specified in Section 34 31 76, TPF Testing and Commissioning.

1.02 REFERENCE STANDARDS

All equipment furnished under this Section shall be in accordance with the latest applicable standards with regard to material, design, construction and testing, except for any specific variations provided in this Section. The standards applicable shall include, but not be limited to, the following:

- A. American National Standards Institute (ANSI):
 - 1. Z55.1 Gray Finishes for Industrial Apparatus and Equipment
 - 2. Z358.1 Emergency Shower and Eyewash Equipment
- B. Air Conditioning and Refrigeration Institute (ARI):
 - 1. 210/240 Unitary Air-Conditioning and Air-Source Heat Pump Equipment
- C. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE):
 - 1. 52.1 & 52.2 HVAC Filters
- D. American Society for Testing and Materials (ASTM):
 - 1. A36/A36M Standard Specification for Carbon Structural Steel
 - 2. A446/A446M Standard Specification for Steel Sheet, Zinc-Coated

(Galvanized) by the Hot Dip Process, Structural
(Physical) Quality

3. D229 Standard Test Methods for Rigid Sheet and Plate Materials Used for Electrical Insulation
 4. E136 Standard Test Method for Behavior of Materials in a Vertical Tube Furnace
 5. E84 Standard Test Method for Surface Burning Characteristics of Building Materials
- E. California Building Standards Commission (California BSC):
1. CBC California Building Code
- F. California Public Utilities Commission (CPUC):
1. CPUC GO 131 General Order – Rules Relating to the Planning and Construction of Substations Located in California.
- G. Institute of Electrical and Electronic Engineers (IEEE):
1. 693 Seismic Design of Substations
- H. National Electrical Manufacturers Association (NEMA):
1. WD1 General Requirements for Wiring Devices
- I. National Fire Protection Association (NFPA):
1. 70 National Electrical Code
 2. 72E Automatic Fire Detectors
 3. 90A Standard for the Installation of Air Conditioning and Ventilation Systems
- J. Occupational Safety and Health Administration (OSHA):
1. General Industry Standards (29 CFR 1910)
 2. Construction Standards (29 CFR 1926)

1.03 RELATED SECTIONS

Related requirements are included in, but not limited to, the following Sections:

- A. 34 31 03 - General Traction Power Requirements
- B. 34 31 13 - Basic Traction Power Materials and Methods
- C. 34 31 19 - Low Voltage Wire and Cable

- D. 34 31 16 - TPF Grounding and Bonding
- E. 34 31 26 – TPF Batteries and Accessories
- F. 34 31 59 - Interlocking Wayside Power Cubicles

1.04 SUBMITTALS

Submit shop drawings, technical data, and certificates for all items of equipment provided under this Section, in accordance with Section 34 31 03, and the following:

- A. Manufacturer's descriptive literature, catalog data, and other information required to demonstrate compliance with the Contract Documents.
- B. Layout arrangement and detailed shop drawings with dimensions of the enclosure with all installed accessories and substation equipment.
- C. Certificates of Compliance for specified enclosure materials and performance.
- D. Structural analysis calculations for building and seismic loadings as detailed below:
 - 1. Structural calculations shall be certified by a structural engineer registered in the State of California.
 - 2. Compare stress capacities/allowable stresses to applied stresses.
 - 3. Include manufacturer's gauge metals cut sheets showing material properties.
 - 4. Clearly define assumptions, loads, constants, and abbreviations used.
 - 5. Confirmation that delivery can be transported legally from point of manufacturing to jobsite.
- E. Heating capacity calculations as detailed below:
 - 1. Provide heating calculations for the winter season at the minimum exterior ambient temperatures and thermostat set points specified in Section 34 31 03, General Traction Power Requirements. Clearly define assumptions, loads, constants, and abbreviations used.
 - 2. Neglect electrical equipment heat contribution.
- F. Air conditioning capacity calculations as detailed below:
 - 1. Provide air conditioning calculations for the summer season at the maximum exterior ambient temperatures and thermostat set points specified in Section 34 31 03, General Traction Power Requirements. Clearly define assumptions, loads, constants, and abbreviations used.
 - 2. Include the heat contributions of all enclosure electrical equipment with

the equipment operating at 100 percent rated continuous load.

- G. Lighting layouts shall be approved by Caltrain.
- H. Duplex receptacle layout shall be approved by Caltrain.
- I. Site installation working drawings including the following:
 - 1. Foundation piers/slabs and door entry pads.
 - 2. Enclosure base anchorage locations.
 - 3. Conduit stub-up locations.
 - 4. Detail of weatherproofing at building joints.
- J. Enclosure and equipment grounding details.
- K. HVAC equipment wiring and schematic diagrams.
- L. Substation (TPS, SWS, and PS) equipment point to point interconnection wiring diagrams and raceway schedules.
- M. Equipment installation staging, site access, and rigging plans, including crane data, placement stability, and swings.

PART 2 – PRODUCTS

2.01 GENERAL

- A. The enclosure shall be designed in accordance with AISC specifications to withstand live roof loading, wind loading, and seismic loading with all equipment and architectural treatments installed based on the service conditions described in the Caltrain 25kV AC Electrification Standard – Chapter 1 and the stresses caused during loading, transportation, and installation. Doors, walls, and roof panels shall be reinforced by braces, stiffeners, and/or structural members as required to provide a rigid and modular structure.
- B. Overall TPS, SWS, PS, and WPC dimensions shall not exceed those indicated on the Construction Drawings. The height of the TPS, SWS, PS, and WPC shall be as low-profile as possible.
- C. The enclosure shall be a totally-integrated weatherproof unit housing the indicated traction power substation, paralleling station, switching station, and WPC equipment. The enclosure shall provide a dry, vermin-proof, and condensation-free, stable internal ambient temperature environment. The enclosure shall be provided with gutters and down spouts at each end as a minimum.
- D. The enclosure structures shall be built in continuous modular sections for final assembly in the field. The height and width of the individual modules shall be within legally transportable limits. The length may vary to suit the design requirements. The manufacturers' complete building shall be assembled, wired,

and bolted together at the manufacturer's plant for testing and then disassembled for transportation. All interconnecting wiring between building modules shall be connected and tested and then disconnected. Connecting modules shall be completely weather-tight while allowing for expansion and contraction between modules. Provisions shall be made for expansion and contraction of all cable, conduit, piping, etc., which crosses between modules. Conductors and assembly pieces shall be carefully marked for rapid, simple field joining.

- E. Galvanized Steel:
 - 1. Steel Sheets No. 11 Gauge or Lighter shall conform to ASTM A653/A653M.
 - 2. Steel Heavier Than No. 14 Gauge shall conform to ASTM A36, and shall be hot-dip galvanized after fabrication in accordance with ASTM A123 and ASTM A153, as applicable. Galvanneal rolled steel may be used for fabrication of power control centers.

- F. All field assembled joints shall be capable of being and shall be properly sealed to prevent ingress of moisture, dampness, and dust, and all shop fabricated joints shall be moisture and dust tight.

- G. The TPS, SWS, and PS buildings shall have an integral floor with a perimeter steel beam and shall be capable of spanning across and being bolted down to the finished concrete piers and beams. Provisions shall be made for lifting and moving heavy equipment into and out of the building. All portions of the floor shall be designed for a minimum load of 250 pounds per square foot and shall be capable of supporting full operating weight of equipment when moving across the floor. Floor openings shall be provided for cables as given in the Construction Drawings. The locations and sizes of these openings may vary, and may need to be adjusted, as decided by Caltrain. All floor openings in the aisle should have flush cover plates.

2.02 ENCLOSURE CONSTRUCTION REQUIREMENTS

- A. The design requirements shall conform to the latest applicable standards of NEMA, ASTM, ANSI, AISI, and NEC. The building shall be constructed for a roof live-load of 30 psf plus all additional roof supported equipment loads and wind load of 25 psf and specified seismic loading.

- B. Normal Design Loads: The vertical roof live-loads, in addition to the applicable dead loads and equipment loads, shall be applied on the horizontal projection of the roof structure. The wind load on the building shall be proportioned and applied as horizontal and uplift velocity pressures. The maximum deflection in roofing or roof panels shall not exceed 1/180th of their spans.

2.03 HEATING, VENTILATION, AND AIR CONDITIONING

- A. Provide redundant, heavy duty, one piece wall-mounted, factory-assembled modular HVAC units as detailed below:
 - 1. The normal substation (TPS, SWS, PS, and WPC) enclosure HVAC

controller set point range is expected to be between 68° F to 78° F. The maintained enclosure temperature for HVAC system design purposes shall be 72° F.

2. Cooling and heating capacities to meet the specified requirements with one unit out of service.
3. The power supply for traction power substations, paralleling stations, switching station, and WPC's shall be from the local utility or auxiliary power (TPS, SWS and PS).
4. Economizer option with built-in exhaust damper to allow user-adjustable volumes of filtered exterior cooling air input under appropriate conditions.
5. Disposable filters adequate for preventing the entry of dust. Filters shall be replaceable pleated micro glass high efficiency filters to ASHRAE Standards 52.1 and 52.2.
6. Digital controller with the following features:
 - a. Compressor current and dirty filter sensors.
 - b. HVAC failure alarm relay outputs that annunciate.
 - c. Alternating master-slave unit operation to provide approximately equal use of both HVAC units, and to preclude simultaneous startup of both units.
 - d. Alarm contact that annunciates when substation interior temperature exceeds 100° F.
 - e. Shutdown contact from SCADA.
7. Cabinet of minimum twenty-gauge galvanized steel with exterior finish capable of resisting a minimum 1,000-hour salt spray exposure, per ASTM B117.
8. Quiet operation as measured from the enclosure interior and exterior.
9. Proven method of leak-proofing at the unit interface with the enclosure.
10. Install the thermostatically controlled HVAC system in accordance with the manufacturer's instructions, complete and ready for operation.
11. If lead-acid batteries are provided, adequate input/output air flow shall be provided to exhaust fumes to a safe level.

2.04 WALLS, CEILING, FLOOR, AND ROOF

- A. Exterior wall panels shall be fourteen-gauge galvanized steel, minimum. Interior walls shall be fourteen-gauge galvanized steel, minimum.

- B. The floor shall be ¼ inch steel plate, minimum.
- C. Building base frame shall be provided with a minimum of two (2) grounding pads at opposite corners. If more than one shipping section, each section should have a minimum of one grounding pad.
- D. The floor shall be designed to accommodate all conditions of load, installation, service and insulation.
- E. The floor, under equipment and immediately in front of equipment, shall provide for equipment glide bars or skids so that repeated equipment removal will not damage the floor.
- F. Floor load designs shall provide for full, safe support of the heaviest equipment item which may be skidded across the floor during removal/replacement, and in no case shall the floor capacity be less than 100 psf providing deflection no greater than 1/360 of span.
- G. Floor surfaces shall have a non-skid waterproof long-wearing floor covering.
- H. Where conduit stub-ups penetrate the floor for access to equipment for cabling, the floor shall be panelized to permit the fabrication and installation of a neat hand access panel near or at the stub-up to facilitate complete sealing of the cable entrance fitting.
- I. The roof shall be fourteen-gauge galvanized steel, minimum, with a minimum slope of three (3) inches.
- J. The interior ceiling shall be fourteen-gauge galvanized steel, minimum.
- K. Where necessary a step to facilitate personnel access shall be provided.
- L. Vault access via the floor shall include a fixed non-conducting ladder with fall protection, if required.

2.05 DOORS AND DRIP SHIELD

- A. The enclosures shall have at least two (2) entry doors located as indicated on the plans. The size of one door shall accommodate the removal of the largest piece of equipment.
- B. Doors shall be equipped with panic hardware consisting of aluminum three-point crash-bar safety latches to permit opening from within under all conditions. The latches shall have tamper-proof locks integrated with entry handles equipped with visual indication that door is locked or unlocked. Single point latches with panic bar can be used within traction power facilities (Traction Power Substations, Switching Station and Paralleling Stations).
- C. All entry doors shall be keyed alike, with provision for re-keying by Caltrain after system commissioning. The locking arrangement will be coordinated with the requirements stated in the Appendices.
- D. Door closers shall be provided and doorstops furnished to hold the door in the

open position. Hinged exterior access doors, with three-point latches and padlocking lugs, shall be provided behind equipment requiring access for cable makeup or maintenance.

- E. The main entry door shall be not smaller than as shown on the plans, and sized to permit removal of the largest item of substation equipment.
- F. All hinged interior and exterior doors providing access to circuit breaker cubicles, control compartments and other equipment, shall have three-point latches and handle stops to hold doors in the open position.
- G. All exterior hardware shall be stainless steel.
- H. All major wall penetrations shall have drip shield measuring at least 3 ½ inches.

2.06 FINISHES

- A. Interior and exterior metal surface finishes: in accordance with Section 34 31 13, Basic Traction Power Materials and Methods.
- B. The exterior of the TPSS/SWS/PS enclosure shall be painted; Caltrain will provide the specific color information to the Contractor during the shop drawing review phase.
- C. Exterior metal floor bottom and base framing (base assembly):
 - 1. All welds shall be ground smooth prior to cleaning.
 - 2. Cleaning shall include grit or high-pressure water blasting followed by phosphatizing to remove all oils, grease and other contaminants.
 - 3. High-build industrial grade epoxy paint coats shall be applied to the entire assembly to providing minimum dry film thicknesses of four (4) mils for the floor and six (6) mils for the sides.
 - 4. Additional black polyurethane paint layer of minimum dry film thickness of four (4) mils shall be applied to the bottom of the base.

2.07 THERMAL INSULATION

- A. Walls and roof are to be insulated R-20.
- B. Doors are to be insulated R-7.
- C. All insulating materials shall have a certified classification of non-combustible as defined by ASTM E136 and ASTM E84.

2.08 INTERIOR ELECTRICAL WORK

- A. Power Receptacles.
 - 1. Provide convenience outlets on all wall surfaces. Wiring shall be complete and in accordance with Section 34 31 13, Basic Traction

Power Materials and Methods and the NEC.

2. Duplex, heavy-duty, 20 A, 120 Vac, 3-wire grounded type receptacle, conforming to UL498, UL943, and NEMA WD1, shall be provided at each entry door near the ac switchgear. All receptacles shall be GFI.
3. A weatherproof, heavy-duty 20 A duplex outlet shall also be provided at each entry door on the exterior wall. The receptacle shall be located behind a vandal proof bolted panel.

B. Conduit, Cable Trays, and Wireways

1. Provide conduit, cable trays, wireways, supports, junction boxes, and related hardware as needed to meet applicable codes and equipment power, control and indication requirements.

2.09 LIGHTING

- A. LED lighting shall be furnished for the interior of each TPS, SWS, and PS, The Contractor shall provide for the following minimum maintained lighting levels:
1. Provide lighting fixtures as required in all spaces to maintain an average illumination level above the aisle floor of at least 322.917 lux (30 foot-candles) for normal lighting and 53.819 lux (5 foot-candles) for emergency lighting, and provide outdoor fixtures at each building entrance. All lighting shall be controlled from suitably located wall switches.
 2. Indoor lighting fixtures shall be industrial type LED as required. Exterior lighting fixtures shall be LED. Fixtures shall be as specified in Section 34 31 69, TPF Exterior Lighting, and Lighting Protection.
- B. Location of lighting fixtures shall be coordinated to avoid interference with overhead raceways or other major wiring and shall not be directly above switchgear. The lighting shall be controlled by a flush mounted single-throw, two-way switch located at each entry door. Three or four way switches to be used if required.
- C. A minimum of two (2) low-power, high-efficiency, combination Emergency/Exit lighting fixtures shall be powered from the traction power substation/paralleling station/switching station auxiliary power system inverter; only one is required in the WPC. Provide controls to energize the lamps automatically upon failure of the ac power when a substation light switch is in the "ON" position only. Lighting shall be furnished and installed in each building enclosure. The units shall be provided with a self-contained battery charging and battery system with automatic switch for power loss. Connection shall be made to the 120 Vac substations/paralleling stations/switching station supply and shall be fully automatic and self-contained in cast housing. The units shall be provided with a test switch and voltage indicator.
- D. Outdoor lighting shall be provided by enclosure-mounted lamp fixtures with unit photo-cell control, located as shown on the plans. Design shall provide a minimum level of 2 foot-candles at ground level within an approximate fifteen-

foot radius.

2.10 FIRE DETECTION AND INTRUSION SYSTEM

- A. For fire detection, reference Division 28 Specifications.
- B. Provide an intrusion detection device on each door. Intrusion detection device shall be actuated upon opening the door by any means and shall be deactivated and activated manually after entry into and departure from the substation enclosure respectively.
- C. Intrusion detection Device No. IDX shall provide annunciation to SCADA upon operation.

2.11 NOISE LEVELS

- A. Interior noise levels: in accordance with OSHA requirements.
- B. Exterior noise levels: in accordance with Section 34 31 03, General Traction Power Requirements.

2.12 PORTABLE FIRE EXTINGUISHER

- A. A dry chemical type portable fire extinguisher, UL rating 3-A: 20-B: C, shall be provided and suitably mounted near each entry door as indicated on the plans.

2.13 WARNING SIGNS

- A. A warning sign shall be installed on each of the four exterior walls of the substation building. Warning signs shall conform to specifications as identified in Section 34 31 13, Basic Traction Power Materials and Methods.

PART 3 – EXECUTION

3.01 COORDINATION WITH FOUNDATION AND ENTRANCE SLABS

- A. Contractor shall coordinate enclosure design and installation with foundation pier/slab and entrance slab installation. Contractor will be responsible for the matching of enclosure anchor locations with piers, and the level mating of door slabs with as-installed enclosure doorways.
- B. Coordinate TPF enclosure finish floor with stairs and landings. Door openings and any railing landings shall also be coordinated to provide adequate clearances and access.

3.02 TRANSPORT

- A. Prepare complete substation enclosures for transport by securing or removal of all loose items.
- B. Remove and separately package all interior and exterior components which are likely to be damaged in transport due to vibration, lifting, or bumping, etc.
- C. Use approved spreader bar for lifting so as not to damage form, fit, or finish of

equipment.

- D. The Contractor shall utilize the services of an experienced and fully bonded rigging contractor to perform all lifting and transport of all TPF enclosures.
- E. A detailed transportation route shall be submitted to Caltrain for approval. The Contractor shall obtain any necessary transportation permits, escort parties and any other items needed to complete the task.
- F. The substation sections shall be wrapped in such a manner as to prevent wind damage to the paint during transport.

3.03 RIGGING

- A. The Contractor shall submit to Caltrain, for the review and approval thereof, sketches and data defining erection, demolition or other hoisting operations used in support of construction. Typical lifting instructions are not to be used. At Caltrain's request, the Contractor shall submit information, data, and sketches for the safe use of equipment. This includes, but is not limited to:
 - 1. Plan view showing locations of cranes, operating radii, with delivery or disposal locations shown.
 - 2. Crane rating sheets showing cranes to be adequate for the lift. Crane and boom nomenclature is to be indicated.
 - 3. Plans and computations showing weight of pick.
 - 4. Location plan showing obstructions, indicating that the proposed swing is possible. Location plan shall also show locations of manholes, underground duct banks and other utilities and infrastructure that could be damaged by crane and support vehicle positioning (vehicle body, wheels and outriggers). Show location and type of cribbing and other materials proposed to prevent damage to this infrastructure.
 - 5. Data sheet listing type and size of slings or other connecting equipment. Include copies of catalog or information sheets of specialized equipment. Detail method of attachment on erection plan.
 - 6. A complete procedure is to be included, indicating the order of lifts and any repositioning or re-hitching of the crane or cranes.
 - 7. Temporary support of any components or intermediate stages is to be shown.
 - 8. A time schedule of the various stages must be shown, as well as a schedule for the entire lifting procedure.

3.04 FIELD INSTALLATION

- A. Mount, re-assemble, and anchor enclosure in accordance with the approved shop drawings and the manufacturer's requirements including joint and

weatherproofing sections of each building.

- B. Re-connect substation components and systems as required and test as specified in Section 34 31 76, TPF Testing and Commissioning.
- C. Grounding connections shall be installed in accordance with the approved shop drawings.
- D. All AC switchgear/equipment shall be confirmed connected to the substation ground bus.
- E. Where enclosures are elevated above grade, provide stairs with railings, see construction drawings for details.

3.05 FIELD TOUCH-UP

- A. Damaged interior and exterior surface coatings shall be repaired, cleaned, and repainted with the same coating system used in the factory painting.

END OF SECTION

SECTION 34 31 93

TPF ENERGIZATION TESTING AND TRAINING

PART 1 - GENERAL

1.01 DESCRIPTION

- A. The Work specified in this Section includes TPF energization and testing, and the training of Caltrain TPF facility operations staff.
- B. Training and support materials shall be provided to enable Caltrain personnel to operate and maintain the new facilities. The training program shall include detailed instructions, demonstrations and supervised hands-on training.

1.02 RELATED SECTIONS

Related requirements are included in, but not limited to, the following Sections:

- A. 34 31 03 - General Traction Power Requirements
- B. 34 31 11 - Substation Supervisory Control and Data Acquisition (SCADA) System
- C. 34 31 13 - Basic Traction Power Materials and Methods
- D. 34 31 76 - TPF Testing and Commissioning

1.03 SUBMITTALS

Submit the following in accordance with Section 34 31 03:

- A. Resumes of field service engineers and instructors.
- B. System energization test procedures and requirements, including safety precautions, energization steps, and checks at each stage of switching; and acquisition of approval from Caltrain.
- C. Training schedule.
- D. Field service engineer's logs.
- E. O & M Manuals for the traction power equipment and facilities.
- F. Training program materials as follows:
 - 1. Furnish a detailed outline of the training course with hourly lesson plans, 90 days before the approved scheduled date for the start of training. The course outline shall include lists of course materials, training aids, and necessary training equipment.
 - 2. Contractor shall submit a complete first draft of the training program prior to delivery of the Traction Power Facility.

3. Contractor shall submit the final copies of the training program prior to start of Traction Power Facility testing.
- G. Training Plan: Provide transparencies (slides) in electronic format, MS PowerPoint.
 - H. Final submittal: After approval by Caltrain, submit the following quantities of the finished documents.
 1. Training Program: One complete reproducible set of printed training program materials and 10 complete copies.
 2. Training Plan: Furnish digital copy containing the training plan Power Point presentations.

1.04 PERSONNEL QUALIFICATIONS

The field service engineers and TPF operation and maintenance instructors shall be qualified to perform the functions as indicated. Submit a resume for each individual nominated a minimum of 60 days prior to the approved scheduled date for the commencement of training, for Caltrain approval.

PART 2 - PRODUCTS

2.01 EQUIPMENT AND SPARES

- A. Provide tools, instruments, calibration devices, meters, and other equipment necessary to connect, monitor, and adjust TPF equipment during start-up testing.
- B. Provide a listing of spare parts to be present when conducting start-up testing.

PART 3 - EXECUTION

3.01 TPF ENERGIZATION

- A. TPF facilities shall be ready for energization only upon successful completion of the testing, adjusting, and calibrating. Procedures shall also conform to other sections pertaining to Traction Power Substations, Switching Stations, Paralleling Stations and Interlocking Wayside Power Cubicles. Notification to Caltrain shall be established when each facility is ready for energization. Ten working days subsequent to the notification, the Contractor will complete arrangements for the provision of the power from the appropriate electric utility companies, if applicable.
- B. After approval is obtained, energize each TPF in accordance with the Caltrain approved plan. Stations that have power transformers shall remain energized a minimum of one week before system integration tests commence. Notification of successful complete energization shall be made to Caltrain. Indication of no-load voltage presence on the AC power switchgear buses and on the low-voltage AC and DC panelboard will be accepted as completed energization.

3.02 TRAINING

- A. Provide on-site training for Caltrain personnel in the operation and maintenance of the Traction Power Facility provided by the contract. Delivery of a single TPSS, PS, or SWS will require a minimum of 16-hour training and delivery of a single WPC will require a minimum of 8 hours of training.
- B. Schedule the personnel training course after delivery of operation and maintenance manuals and 30 days prior to the energization of the facility. The exact starting date for the personnel training course will be as directed by Caltrain. Schedule the personnel training course between 8:00 A.M. and 5:00 P.M., Monday through Friday.
- C. Establish an objective grading system to report the progress of each trainee during the course. Grading shall be kept confidential and furnished only to personnel designated by Caltrain.
- D. Space for classroom lectures and practical training on equipment and training equipment such as slide projectors, movie projectors, screens, easels, and similar equipment will be furnished by Caltrain.
- E. The Contractor may use spare parts furnished under this Contract as training aids and for demonstration of and practical exercises for adjusting, testing, disassembly, and assembly of equipment. Ensure that the spare parts used for training are repackaged and returned to storage in acceptable condition for installation in the system.
- F. Practical training on installed traction power equipment is required.
- G. Content of the operations training course shall include, as a minimum, description of procedures and in-service training or simulation for placing system into initial operation, making necessary adjustments while equipment is in operation, and shutting down the equipment. It shall also include trouble shooting procedures and thorough instruction in emergency procedures. This course shall be directed toward engineers and journeyman electricians who are experienced in operation of AC electrical equipment, but who, however, do not have prior experience in operation of the traction power equipment used for commuter rail transit systems. The course shall prepare the trainees for operation of the equipment.
- H. Content of the maintenance training course shall include, as a minimum, review of basics of safety and electrical equipment maintenance; and classroom description and in-service training on maintaining, testing, trouble shooting, adjusting, assembling, and disassembling all items of equipment. This course shall be directed to technicians comparable to journeyman electricians who do not have prior experience in maintenance of traction power equipment. The course shall prepare the trainee for maintenance of traction power equipment. Classroom training shall begin with an education of the anatomy and physiology overall project from utility feed to train to develop an understanding of system operation of each different style substation and how they work together prior to detail operation/maintenance/trouble shooting education.
- I. Any printed material or audio-visual material prepared by the Contractor as teaching aids shall become the property of Caltrain at the completion of the training program.

- J. Class size for both courses is estimated to be 15; five supervisory engineers and 10 technicians.
- K. Training Plan: Develop a training plan that documents the Contractor’s design for training, maintenance and engineering personnel, technicians, supervisors, and management personnel. The plan shall include but will not be limited to:
 - 1. Performance objectives that state the expected behavior, the conditions under which performance will occur, and the measures and standards to be applied.
 - 2. Lesson plans that include the sequence of activities, an outline of the content learning strategies to be used (e.g., classroom presentation, hands-on practice, audio/video presentation, etc.).
 - 3. Resources required, such as equipment and shop space.
 - 4. A schedule for delivery of training course to all designated Department personnel. The size of classes, time and location of the training must be approved in advance by Caltrain. Include scheduled time allocated to training Department trainers.
- L. Training Materials: Provide materials to support the training courses, including: instruction guide, training aids, student workbooks, and operation and maintenance manuals.
 - 1. Instructor Guide: Provide instructor guides containing: course outline, agendas, objectives, lesson plans, training aids, presentation guidelines, suggested discussion questions, and criteria for measuring student performance.
 - 2. Training Aids: Provide training aids, such as mock-ups, scale models, and overhead transparencies or PowerPoint slides. All training aids shall be of durable construction and shall become the property of the Department. Verify that any equipment or tools used during training are in good working condition both before and after training sessions.
 - 3. Student Workbooks: Provide student workbooks that include course objectives, course agenda, schedule of sessions, copies of overhead transparencies. Lecture outlines, and any additional printed material used during the course.
- M. Class Lectures/Presentations: Provide experienced trainers who are knowledgeable about the subject matter. They must be able to answer questions and give detailed explanations and demonstrations. All presentations shall be made in English. To help Department trainers become familiar with the content and delivery of the training, the Contractor shall videotape their classroom presentations or provide staged videotaped versions in digital format. The Department will furnish taping equipment. The Contractor shall provide personnel to operate the camera.
- N. The Contractor shall designate the total number of hours allocated for training of each work group.

END OF SECTION