City and County of Honolulu
Department of Transportation Services
Rapid Transit Division (RTD)

CORE SYSTEMS
DESIGN-BUILD-OPERATE-MAINTAIN
CONTRACT

TECHNICAL PROVISIONS
TP-8 DIVISION 34
TRANSPORTATION

ISSUE FOR PROPOSALS – NOT FOR CONSTRUCTION

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SECTION 34 20 01
TRACTION ELECTRIFICATION – GENERAL REQUIREMENTS

PART 1 – GENERAL

1.01 SUMMARY

A. Description:

1. The Work of this Section includes the general requirements for the design, procurement, and installation of the Traction Electrification System (TES) facilities equipment including the Traction Power Substations (TPSS), the Gap Breaker Station (GBS), related TES equipment, and interfaces to other Core Systems Design-Build Operate-Maintain (DBOM) systems as specified herein and as indicated in the RFP Plans. The Work also includes for coordinating the TES interfaces with the Guideway Contractor (GC) and the Maintenance and Storage Facility Design-Build Contractor (MSFDBC) work requirements.

2. The Work includes coordinating with the interfaces for the Electrically Operated Disconnect Switches (EOS) as specified in Section 34 20 55 – Wayside DC Disconnect Switches. The Work also includes coordinating with the interfaces for Emergency Trip Station / Blue Light Station (ETS/BLS) equipment.

3. The Work also includes coordinating with the MSFDBC for the Train Control System interface with the TES facility equipment, deenergization of Contact Rail sections at the Maintenance and Storage Facility (MSF) Yard and Mainline, for the MSF secondary access entrance described in Section 34 44 00 – Train Control System.

B. Section Includes:

1. Testing
2. Manuals
3. Training
4. Initial Provisioning

C. Related Sections:

1. Section 26 05 26 – Grounding and Bonding for Electrical Systems
2. Section 26 05 29 – Hangers and Supports
3. Section 26 05 33 – Raceway and Boxes for Electrical Systems
4. Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems
5. Section 26 05 53 – Identification for Electrical Systems
6. Section 26 42 01 – Corrosion Control and Cathodic Protection
7. Section 28 37 00 – Wind Detection
8. Section 34 20 05 – Prefabricated Enclosures
9. Section 34 20 18 – Traction Electrification System MSF Grounding Requirements
10. Section 34 20 19 – Traction Electrification System Grounding Requirements
11. Section 34 20 40 – Emergency and Transfer Trip System
12. Section 34 20 45 – DC Control Power System
13. Section 34 20 51 – Traction Electrification System Interface Requirements
14. Section 34 20 52 – Traction Electrification System MSF Interface Requirements
15. Section 34 20 55 – Wayside DC Disconnect Switches
16. Section 34 20 60 – Traction Power Cables
17. Section 34 20 70 – Traction Electrification System Interfaces
18. Section 34 20 80 – Traction Electrification System Testing
19. Section 34 44 00 – Train Control System

1.02 PRICE AND PAYMENT PROCEDURES
A. General: Separate measurement or payment will not be made for the Work required under this Section. All cost in connection with Work specified herein will be considered to be included with the related item of work in the General Conditions requirements, or incidental to the Work.

1.03 CODES, STANDARDS, AND RECOMMENDED PRACTICES
A. American Railway Engineering and Maintenance-of-Way Association (AREMA):
   1. AREMA Manual for Railway Engineering Publication
B. American Welding Society (AWS)
C. ASTM International (ASTM):
   1. ASTM B766 Standard Specification for Electrodeposited Coatings of Cadmium
D. Hawaii Occupational Safety and Health Administration (OSHA) Standards
E. Institute of Electrical and Electronic Engineers (IEEE):
   2. IEEE C37.2 IEEE Standard Electrical Power System Device Function Numbers and Contact Designations
F. International Building Code (IBC)

G. National Fire Protection Agency (NFPA):
   1. NFPA 1 Uniform Fire Code
   2. NFPA 70 National Electrical Code
   3. NFPA 70E Electrical Safety in the Workplace
   5. NFPA 130 Standard for fixed Guideway Transit and Passenger Rail Systems
   6. NFPA 780 Standard for the Installation of Lightning Protection

H. Regulations of the Hawaii Public Utilities Commission

I. USA Department of Labor Federal Occupational Safety and Health Administration (OSHA) Standards

1.04 DEVICE NUMBERS

A. Device function numbers cited in these Specifications and RFP Plans are in accordance with IEEE C37.2, or as indicated.

1.05 SUPPLIER QUALIFICATIONS FOR TES FACILITIES

A. All TPSS and GBS shall be designed and built by one product manufacturer, referred to as the traction power equipment supplier. Individual equipment items, however, may be the products of different manufacturers.

B. The TPSS and GBS supplier must have engineered, fabricated, assembled, and delivered a minimum of $10 million worth of TPSS over the last 10 years, continuing up to the Bids due date of the Contract. A minimum of 5 years of such experience is a prerequisite.

C. The lead engineer from the TES equipment supplier organization, in charge of the design of the TES facilities, must have project-proven experience in the design and manufacture of traction substations, and shall be subject to approval by the City.

D. Major equipment furnished under this DBOM Contract, such as rectifiers, transformers and switchgear, shall be proven standard products, or equivalent to the standard products, of manufacturers engaged in the production of such equipment for at least the past 5 years.

E. The rectifier transformer manufacturer must have a minimum of 5 years manufacturing experience with power rectifier-transformers with a proven successful record of manufacturing, 3-winding rectifier transformers for industrial or rail transit applications, with such transformers presently in regular service.

F. The lead engineer from the rectifier transformer manufacturer organization, in charge of the design of the rectifier transformers, must have a minimum of 5 years of project-proven experience in the design of 3-winding rectifier transformers.

G. Components of major equipment, such as relays, control switches, and protective devices, do not have to meet the 5-year experience requirement.
H. The manufacturer of the silicon diode rectifier must have a minimum of 5 years experience in the design and manufacture of traction rectifiers and must have a silicon diode rectifier of proven design in either transit or similar industrial applications.

1.06 PERFORMANCE REQUIREMENTS

A. Provide coordination, equipment, components including the TPSS and GBS facilities that meet the following requirements:

1. Determine the substation and GBS locations, spacing, and ratings using a load flow study of the rail electrification network using a computer based simulation model. The analysis shall use the operational criteria provided in the Design Criteria, Part 4, Section 13.5.3. Validate the quantities of substations and gap breaker stations and the locations as indicated on the RFP Plans, based on his calculations and load flow analysis, using the HHCTCP Vehicle Data.

A final Traction Power Report and all applicable calculations shall be submitted to the City for approval prior to the fabrication of the traction power and gap breaker stations.

2. The design shall include provisions for installation of all large equipment, such as circuit breakers, rectifier, and the rectifier transformer. Generally, the traction power facilities, TPSS, and GBS shall be of the self-contained, walk-in, modular type design, typical of the unit substations supplied for dc Transit Systems.

3. TPSS facilities serve the purpose of transforming the 12.47 kV or 11.5 kV ac power from the Hawaiian Electric Company (HECO) utility system to a nominal 750 Vdc system voltage, which is then distributed to the contact rail system. TPSS include medium voltage ac switchgear, rectifier transformers, traction rectifiers, dc switchgear, and auxiliary equipment and devices as indicated in the RFP Plans.

4. The design shall include provisions for replacement of all large equipment, such as circuit breakers and the rectifier transformer.

5. The design shall provide for emergency access to and egress from the substations in accordance with local Fire and Building Code and NFPA 101.

6. The design shall provide for emergency lighting and exit signs in accordance with local codes.

7. The design working space area shall be free of obstruction in front of meters, service panels, protective relays, and electric equipment for safe access to all electric equipment and metering. Working space shall be maintained, as prescribed by the installed equipment manufacturers recommendations, and requirements and code requirements. Aisle width shall allow for convenient removal of the draw-out ac and dc circuit breakers and as required by NFPA 70 E requirements.

8. Provide safety personnel protective equipment (PPE) for each TPSS and GBS including, personnel protective suits, facemasks, blast shields, aprons, and gloves in accordance with the NFPA 70E and Hawaii OSHA standards and regulations. Submit calculations showing the adequacy of the products supplied to meet these standards for the electrical operating levels of the installed equipment.
9. Provide within each TPSS and GBS adequately sized ground cable assemblies with clamps for temporary ground connections to allow safety grounds to be applied to equipment.

10. Corrosion drainage panels, drainage cables, diodes, and associated raceways and monitoring devices to mitigate stray dc currents shall be provided. TES equipment shall be designed to resist atmospheric air-induced corrosion. See Section 26 42 01 – Corrosion Control and Cathodic Protection and Section 26 05 33 – Raceway and Boxes for Electrical Systems, for additional requirements of the corrosion control system. Atmospheric air-induced corrosion within TES systems shall also be designed with provisions to mitigate their effect on the TES equipment.

11. The design of the TPSS and GBS shall have a life expectancy of 30 years.

12. The Fire Alarm System shall provide for local and remote trouble and fire alarms including shutdown of ventilation equipment on smoke or heat detection.

13. Ground test stations, located near the opposite ends of the TPSS and GBS, shall be provided for testing of the equipment ground grid. See Section 34 20 18 – Traction Electrification System MSF Grounding Requirements, Section 34 20 19 – Traction Electrification System Grounding Requirements, and the RFP Plans.

14. Generator Receptacles shall be provided to allow for Portable Generator to power the TPSS and GBS ac auxiliaries including the 125 V dc Battery Charger and lighting circuits as indicated in the RFP Plans. Determine the size and type of generator plug and receptacle for the generator they will provide pursuant to the requirements of Technical Provision TP-03, “O&M Performance Requirements”.

15. Foundations are to be provided under Section 34 20 51 – Traction Electrification System Interface Requirements and Section 34 20 52 – Traction Electrification System MSF Interface Requirements. Coordinate and provide all necessary parameters, including weights, dimensions, or other pertinent data to the Guideway DB Contractor and the MSFDBC for the construction of the foundations.

16. Emergency Trip System (ETS) and Transfer Trip System shall be provided as indicated within these Specifications and the RFP Plans. In general, Blue Light Stations with ETS Pushbuttons shall be provided at the passenger stations, the TPSS and GBS entrance doors, and within the MSF Yard. See Section 34 20 40 – Emergency and Transfer Trip System, and the RFP Plans for further details.

17. The TPSS and GBS noise limits shall comply with the Honolulu Noise Ordinance and as described herein.

18. For Lightning and associated Isoceraunic Conditions, the design shall include lightning protection of the TPSS and GBS for a 7 thunderstorm-days-per-year isoceraunic zone in accordance with UL 96 A – Lightning Protection, and NFPA 780 lightning protection requirements. The HECO medium voltage underground and open power supply cables and the Track Running Rail shall be provided with properly coordinated lightning arresters. See Design Criteria Chapter 3 – Environmental and the RFP Plans for further requirements.

19. Coordinate with the MSFDBC and the Guideway DB Contractor for all interfacing for HECO requirements. See Section 34 20 70 – Traction Electrification System Interfaces, for further requirements.
20. Provide each traction power equipment assembly with thermostatically controlled adequately sized space heaters to prevent moisture contamination of the internal components.

21. Provide within each TPSS and GBS a first aid kit in accordance with OSHA and local ordinances.

22. All electronic devices, relays, and relay systems shall comply with IEEE 37.90 and 37.91 standards.

23. Provide coordination for the Electrically Operated Disconnect Switches (EOS) equipment as specified in Section 34 20 55 – Wayside DC Disconnect Switches, interface raceways, controls, and indications with the MSF Operations & Service Building facility DB Contractor for the proper installation and operation of these Disconnect Switches.

24. Provide coordination for the Train Control System interface with the TES facility equipment for deenergization of Contact Rail sections of the MSF Yard and Mainline of the MSF secondary access entrance described in Section 34 44 00 – Train Control System, and as indicated in the RFP Plans.

25. All TPSS and GBS facilities shall comply with NESC, NFPA 70, NFPA 130 code, and AREMA recommended practices and requirements.

26. Coordinate with HECO on the utility service connection requirements and the provision of remote metering signals for kilowatt usage and demand as indicated in the Contract Documents. It is the responsibility of the Core Systems Contractor to consult with and obtain approval from the City before selection and final design of these HECO interfaces.

1.07 SUBMITTALS

A. General: Refer to General Conditions requirements for Submittal Procedures, and for Shop Drawings, Product Data, and Samples.

B. Product Drawings: Submit product drawings in accordance with the requirements for individual product submittals and shall be identified on the Contractor Print Transmittal form with the Submittal numbers. Product drawings shall show the dimensions and internal mechanical and electrical details and shall include, but not be limited to, wiring and connection diagrams, schematics, and assembly drawings. Product drawing information shall include the following:

1. Internal physical arrangement and assembly of detail parts in each item of equipment
2. Wiring connections and numbers between devices and equipment terminal blocks
3. Elementary schematic drawing number where the device appears
4. Brief description of the device functions and special features
5. Manufacturer's name
6. Manufacturer's part, model, type, or style number
7. Device rating
8. Number, type, and rating of contacts, if applicable

9. Internal schematic diagrams

10. Outline of device and external terminal locations and numbers

C. Design Plans: Submit Design Plans under their applicable Submittals Schedule number to the City for approval. Design Plans shall include the following types of plans:

1. Arrangement plans showing locations of control and protective devices on panels.

2. Floor plans of complete equipment assemblies showing dimensions necessary for installing equipment, equipment base details, available space for entrance of power and control cables, and dimensions and weights of major sections.

3. Section views of each non-identical unit showing bus and equipment locations and locations of outgoing power and control terminals. Plans shall be in sufficient detail to illustrate accessibility for maintenance and for adjustments while energized.


5. Schematic diagrams of equipment assemblies showing devices, wire numbers, internal and external wiring. Diagrams that do not portray the physical wiring of the panel will not be approved.

6. Schematic diagrams and technical data for the automatic reclosing and load measuring system.

7. Exposed raceways within the guideway deck, the base of guideway column pier to the deck including pull boxes for traction power, communications, emergency trip, transfer trip, and cross bonding.

8. The Emergency and Transfer Trip Systems Design Plans shall show all aspects of the complete system including interfaces to other systems.


10. Structural Design Plans for dc Equipment and Outdoor Enclosures.

11. Site Arrangement Design Plans to be used for all bus duct arrangements and installation.

12. Equipment installation drawings including cabling and conduit requirements.

13. Nameplates and signs showing legends, letter sizes, material, and color information.

14. All plans submitted will be in CAD format as defined in the Design Criteria and the City requirements. Submit all CAD plans in electronic form in compliance to the CAD standards set up and approved by the City about symbol, color, font, format, and general layout.

D. Design Calculations: Submit the following design calculations for approval:

1. Load Flow study, calculations, and Final Report

2. Design calculations for the transformer-rectifier unit
3. Short circuit calculations and relay coordination study
4. Indoor and outdoor lighting calculations
5. Heating and Ventilation System Calculations
6. 208 V ac and 125 V dc system design calculations, including cables and equipment sizing
7. Design Calculations for Miscellaneous Systems and Devices
8. Structural Design Calculations for traction power prefabricated enclosures, foundations, and enclosures
9. Seismic Calculations (Including Bracing and Support of Equipment and Devices)
10. Reliability Calculations of Negative Grounding Device and of Electronic Devices and Components of the dc switchgear equipment and associated protective relays
11. Noise level calculations and related abatement measures
12. PPE calculations for the personnel protective suits, facemasks, and gloves indicating the level of protection met

E. Prepare and submit the following after return of approved Design Plans and calculations:

1. Connection diagrams showing the internal wiring and terminal block arrangement and identifying each outgoing power and control terminal.
2. Interconnection diagrams showing the terminal blocks and connections to external equipment, panels, and devices. Cable numbers and references to internal and external wiring of the equipment shall be indicated.
3. Detailed instructions for connecting the various shipping sections together complete with connection diagrams. The connection diagrams shall identify the terminals to be connected between the shipping sections and the type and size of cables required for the connections.
4. Submit conduit and cable schedules and block diagrams shall be submitted as and any atypical installation that does not match with the manufacturers typical substation plan, wiring, or installations.
5. Equipment nameplate data, catalog cuts, data sheets, and recommended spare parts list.
6. Relay coordination study, complete with short circuit current and relay setting calculations, and protective device coordination curves. Submit coordination curves on logarithmic paper showing relay and trip device coordination for all equipment for transformer/rectifier unit operations. Relay coordination study shall be performed by the manufacturer supplying the rectifier units. Indicate the limits of damage to the rectifier transformer due to fault currents on the coordination curves.
7. Switchgear breaker test value of the transient recovery crest voltage and the time to reach transient recovery crest voltage.
8. Any supplementary data required by the City to assure that the RFP Plans and these Specifications have been accurately interpreted.

9. Transformer data including rated kVA, frequency, primary and secondary voltages, percent taps, polarity, impedance and certification of transformer performance efficiency at indicated loads, percentage regulation at 100 percent and 80 percent power factor, no-load and full-load losses in watts, percent impedance at 167 degrees Fahrenheit, hot-spot and average temperature rise above 104 degrees Fahrenheit ambient temperature, sound level in decibels, and standard published data.

10. Design Submittal: For the raceways and designs of the TES facility buildings, comply with the performance requirements and Design Criteria. All analysis data and Design Plans and calculations shall be prepared, signed and sealed by a qualified responsible Professional Engineer registered in the State of Hawaii. Where seismic calculations and designs are required, the plans shall be stamped by a Professional Engineer registered in the State of Hawaii qualified to provide PE Seismic stamps on the plans.


H. Installation Drawings: Submit installation drawings to the City for approval 120 days prior to scheduled site equipment delivery. Installation drawings shall include, but not be limited to:
   1. Mounting details
   2. List of items to be installed
   3. Locating dimensions and associated tolerances
   4. Detailed Bill-of-Material
   5. Special installation or process requirements
   6. Special inspection or test requirements

I. Final Configuration As-Corrected Plans: Prior to completion of the Contract, all City-approved changes shall be incorporated by the Contractor into all submitted plans and documents. The As-Corrected Plans shall meet the General Conditions requirements.

J. Other Submittals: Other submittals shall be furnished upon request for the City’s approval to verify compliance of all equipment and materials with the RFP Plans. These submittals shall include in addition to shop drawings, catalog cuts, certifications of compliance, or other substantiating information or samples of material items as necessary. Certified test reports shall be submitted at least 30 days prior to the shipment of the equipment and materials. Test reports shall include seismic test results and calculations for equipment enclosure mountings including battery racks to verify seismic and wind loads for outdoor substation enclosures.

1. This book is to include, but not be limited to one copy each of the Contractor's product and equipment drawings and shall also include, but not be limited to, drawings of the principal products of subcontractors or suppliers.

2. The drawings shall be blue or black line on a white background, be 11 inches by 17 inches in size and bound in volumes.

3. Submit two copies of this Book of Product and Equipment Drawings to the City for review and approval three weeks prior to the Final Design Review.

L. Product Data:

1. Modify manufacturers' standard schematic drawings to delete information that is not applicable to the Contract. Supplement standard information with additional information applicable to this Contract.

2. Modify manufacturers' standard catalog cuts, brochures, diagrams, schedules, performance charts, illustrations, calculations, and other descriptive data to delete information that is not applicable to the Contract. Indicate dimensions, clearances, performance characteristics, capacities, wiring and piping diagrams, and controls.

3. Modify manufacturer's printed installation, application, and instructions to delete information that is not applicable to the Contract.

M. Installation Manual: Prepare an Installation Manual and submit to the City for approval no later than 90 days prior to the associated installation.

1. The Installation Manual shall be used by the Contractor and sub-contractors during installation. The City will also utilize the manual to conduct the Installation Verification as required herein.

2. The manual shall include, but not be limited to, all the installation practices and procedures that the Contractor plans to use to accomplish the installation of the TES and shall be kept current at all times. Ensure that all updated contents of this manual are submitted to the City on a timely basis (within 30 days) when any revisions are approved and incorporated in any of the drawings or procedures contained therein. The Installation Manual shall include, but not be limited to, the following:
   a. A Table of Contents identifying all pages of the manual by revision and date
   b. A list of the applicable sections of electrical codes and National and Industry Standards applicable to the installation
   c. A list of all installation drawings by number, revision, title, and approval status and a copy of each drawing reduced to B size (11 inches by 17 inches)
   d. All City-approved typical and standard drawings reduced to B size (11 inches by 17 inches)
   e. Provide magnetic media in accordance with the requirements of the General Conditions requirements

N. Test Plan, Procedures, and Reports: Factory and field tests plans, procedures, and reports shall be submitted in accordance with the requirements of the General Conditions, Section
O. Submit the Systems Assurance Program Plan (SAPP) as required in accordance with the Design Criteria Chapter 24 – Systems Assurance.

1.08 QUALITY ASSURANCE
A. General: Refer to the General Conditions requirements for quality assurance requirements and procedures.
B. Comply with all applicable Federal, State, and Local Laws, Regulations, and Codes including those referenced in Article 1.03.

1.09 DELIVERY, STORAGE, AND HANDLING
A. Ship each item of equipment and materials securely wrapped, packaged, and labeled for safe handling in shipment and to avoid damage.
B. Store materials in secure and dry storage facility. Provide heaters where necessary to maintain dry area.
C. Provide loose components securely tied down during shipment.
D. Provide Shipping splits considering the following restrictions:
   1. Site limitations
   2. Transportation considerations

1.10 WARRANTY
A. The Core Systems DBOM Contractor suppliers shall warrant that their products are free from defects. Warranty shall conform to the requirements of the General Conditions requirements.

PART 2 – PRODUCTS

2.01 GENERAL EQUIPMENT CONSTRUCTION
A. General Requirements:
   1. All indoor equipment heights shall be limited to 8 feet. If Contractor's standard design is more than 8 feet high, redesign the equipment to meet the 8-foot limit without compromising the integrity of the standard design or clearance requirements.
   2. The surfaces of the equipment shall be smooth, free of gaps, burrs, sharp edges, wrinkles, waves, and blemishes, and shall have uniformly rounded corners with constant radii.
   3. Unless specified otherwise, all outdoor hardware such as hinges, bolts, nuts, and screws shall be stainless steel. Cadmium plating, where specified, shall be in accordance with ASTM B766.
4. Full height doors for equipment such as switchgear, traction transformer rectifiers, and cabinets shall have 3-point locking latches and 1/4 turn "tee" handles. For doors 4 feet or less in height, 2-point locking latches shall be permitted. Each door shall be provided with a cylinder lock or provision for padlock.

5. Openings and mounting holes for front mounted indicating and control devices shall be cut out, drilled, or punched without marring or distorting the exposed finished surfaces.

6. Surfaces to be welded shall be clean and free from dirt, rust, and other foreign materials in accordance with industry standards. All welding shall be performed by electric arc method or resistance spot welding and the process shall conform to the standards of the American Welding Society.

7. Equipment openings shall be provided with 1/2-inch screen mesh to preclude the accidental entry of hand tools and other equipment.

8. Equipment enclosures shall be provided with ground lugs to meet NEC grounding requirements. See Section 26 05 26 – Grounding and Bonding for Electrical Systems, Section 34 20 18 – Traction Electrification System MSF Grounding Requirements, and Section 34 20 19 – Traction Electrification System Grounding Requirements.

B. Structure:

1. All enclosing structures shall have sufficient structural reinforcement to ensure that the surfaces remain plane and plumb and to provide necessary strength and rigidity during shipment, installation, and operation.

2. Equipment enclosures shall be designed to permit lifting by jacks or slings.

3. No assembly shall become detached from its mountings or fail to meet all operating requirements after being subjected to a force equal to half its weight, applied in any direction, through its approximate center of gravity.

4. Each enclosure or structure shall be designed and constructed to withstand wind loads determined in accordance with the requirements of the International Building Code and Article 2.13 herein.

C. Arrangement:

1. Arrangements and locations of equipment, devices, and components shall be as indicated.

2. Where such arrangements and locations are not indicated, submit drawings for City approval.

3. The equipment arrangements indicated are intended to fit the available spaces while providing adequate personnel safety and accessibility for maintenance. The dimensions indicated for each piece of equipment are typical. Prepare equipment arrangement drawings using actual dimensions of individual equipment and maintaining the same minimum equipment clearances and aisle widths. Equipment clearances and aisle widths shall be increased, if required, for normal operation and maintenance of equipment. Building size can be reduced provided that the specified minimum clearances and aisle widths are maintained.
4. All equipment and components shall be readily accessible for inspection, maintenance, adjustment, and reading of data. Protective relays and other devices from which data are to be read shall be mounted semi-flush on the front panels.

5. All control devices mounted on front panels and all those requiring replacement or adjustment inside panels shall be limited to a mounting height of 6 feet.

6. Devices not on the front panels shall be mounted on the surface of internal panels, accessed by opening the hinged front panel.

7. Each device shall be located and wired so that it can be serviced without removing the device or other devices.

8. The devices shall be plumb and square with the lines of the panel, and mounted as recommended by the manufacturer.

2.02 STANDARDIZATION

A. Like components of the equipment, and equipment providing the same functions, shall be the products of a single manufacturer, unless otherwise indicated or approved by the City.

B. Like parts of duplicate units shall be interchangeable.

C. Units of the same rating and providing the same function shall be identical and interchangeable.

2.03 PROHIBITED MATERIALS

A. No polychlorinated biphenyl (PCB), asbestos, or other materials with known toxicity posing health hazard upon handling and human contact shall be used in any parts or products of the traction power facilities.

2.04 NAMEPLATES

A. Nameplates shall be provided for all equipment, materials, devices, and cabinets. The nameplates shall conform to the requirements indicated in the applicable specifications and standards whenever such requirements are indicated. The legends for all nameplates shall be submitted for approval.

B. Unless otherwise indicated, nameplates shall be three-ply laminated phenolic plates with beveled edges, engraved through the white face to expose the black core. Lettering shall be condensed gothic, applied using a rounded or square cutter. V-shaped grooves will not be acceptable.

1. Nameplates identifying major equipment shall have lettering not less than 2 inches in height. Provide two nameplates, one on the front and the other on the rear of each equipment cubicle. Each nameplate shall be labeled with two lines: the first line shall be a descriptive identifier, and the second line shall be the City standard designator for the cubicle.

2. Nameplates for relays, meters, control and instrument switches, fuses, and auxiliary devices shall have lettering not less than 1/8-inch in height. For protective and auxiliary relays, the nameplate inscription shall include device number and function. The nameplates for fuses shall include fuse rating and circuit identification.
3. Traction power facilities shall be furnished with high contrast reflective proof nameplates identifying TPSS and GBS site locations by fire and emergency response teams. They shall be mounted on the entrance gates and at the Blue Light Station locations and include facility name, as indicated in the RFP Plans Master Single Line Diagrams, in 4 inch font lettering and facility street address in 3 inch font. Nameplate type shall be as shown on the RFP Plans.

C. Two nameplates shall be provided on each nominally operating voltage rated 12.47 kV ac, 11.5 kV ac, and 775 V dc equipment assemblies, and the rectifier transformer cubicles: one on the front, and one on the back, with the legend, "DANGER HIGH VOLTAGE".

1. These nameplates shall be three-ply laminated phenolic, engraved through the red face to expose the white core.

2. Lettering shall be not less than 2 inches in height, condensed gothic, engraved with a rounded or square cutter. V-shaped grooves will not be acceptable.

D. Nameplates shall be fastened in place with stainless steel screws or bolts.

2.05 SPECIAL TOOLS

A. Furnish for each traction power facility with one set of all special tools required for the erection, operation, and maintenance of the equipment at that location.

B. Include special relay tools recommended by the relay manufacturer.

C. Include special relay tools recommended by the relay manufacturer.

D. Include feeler gauges or instruments that are required or recommended by the manufacturer maintenance and operations manuals.

E. If the arc chute assembly of the dc breakers weighs more than 50 pounds, and if it is necessary to lift the assembly for inspection and maintenance, a lifting device, such as a chain link manual hoist mounted in the ceiling or a rolling lifting device with appropriate pneumatic, chain crank or with motor operated device, shall be provided in each TPSS and GBS.

F. Programmable Logic Controllers (PLC) or microprocessor based devices, Multifunction Protective Relays (MFPR) furnished under this Contract shall require external computers to reprogram the application software or change device settings. Provide two sets of the required programming equipment including all hardware, software, software license accessories, and related instruction manuals. Provide and label all software program versions to be used.

2.06 NOISE LEVELS

A. Design the TES facilities to meet the specified maximum allowable noise levels. Equipment design, enclosures with acoustic mitigation capability, and other measures, as appropriate, shall be employed to achieve compliance with the audible noise level criteria.

B. The noise level outside the traction power facility, measured at a distance of 5 feet from the TPSS wall during operation at No load, shall not exceed 55 dB. The noise limits shall be reduced by 5 dB if the noise has pure tones or contains an audible screech, whine, or hum.
C. The noise level inside the prefabricated enclosures, measured at a distance of 5 feet from any equipment during operation at 150 percent substation load, shall not exceed 70 dB.

2.07 EQUIPMENT RELIABILITY

A. Mean time between failure (MTBF) for equipment such as ac and dc power circuit breakers, Rectifiers, Transformers, and Negative Grounding Device with electronic and microprocessor-based components shall be no less than 10,000 hours. The MTBF rating shall apply to incidents that prevent equipment operation due to failure of electronic or microprocessor-based component and their interfaces. Furnish reliability calculations to support equipment MTBF requirements. See Design Criteria Chapter 24 – Systems Assurance, for further requirements of reliability.

2.08 POWER FOR AUXILIARY DEVICES

A. Power for all devices and their subsystems used for control, indicating, or supervision functions shall be derived from the 125 V dc system, as specified in Section 34 20 45 – DC Control Power System.

2.09 FAILURE OF ELECTRONIC DEVICES

A. Electronic devices, including microprocessor-based devices, shall be equipped with self-monitoring and self-test features. As a minimum, these devices shall be provided with local indication of device failure, visible on the front panel of the cubicle on which the device is located. Where device failure affects the operation of the main power circuit that it serves, or causes an unsafe condition, device failure shall be indicated on the station Annunciator, and an Alarm sent to the Operations Control Center. A summary alarm annunciation shall be used for local and Operations Control Center alarms.

2.10 RFP PLANS

A. The RFP Plans define functional requirements for the traction power system equipment. Additional functional requirements are defined in these Specifications. The RFP Plans and the requirements herein form the basis for the Core Systems DBOM Contractor to design, develop, and provide all details, appurtenances, and devices necessary to furnish a complete and operable TES facility, including its interfaces with other subsystems.

B. Layouts and site arrangement drawings included in the RFP Plans show approximate equipment dimensions and general orientation of equipment. Update these drawings using actual dimensions of furnished equipment. Clearances between equipment, maximum equipment height requirements, and equipment orientation and arrangement as indicated shall be maintained and shall not be modified without written approval by the City. Additional clear space shall be provided as required to permit unobstructed equipment maintenance, cubicle door operation, racking of breakers in and out of cubicles, servicing of equipment and devices inside the cubicles, cable termination work, and other equipment installation, operation and maintenance work.

2.11 ENVIRONMENTAL REQUIREMENTS – TEMPERATURE

A. All TPSS and GBS Equipment shall be designed, fabricated, and environmentally tested to operate in the temperature range as defined in the Section 34 20 05 – Prefabricated Enclosures.
B. Exterior Equipment: Exterior equipment such as externally mounted light fixtures, conduits and electrical components shall be designed, fabricated, and environmentally tested to operate in the temperature range as stated in Design Criteria Chapter 3 – Environmental.

C. Interior Equipment: Interior equipment consisting of PLC, LCD Screen, and MFPR and all other components required to support the TPSS and GBS operation shall operate without performance degradation while operating within the parameters identified herein. The equipment and devices inside traction power facilities shall be designed and rated for operation at 122 degrees Fahrenheit ambient temperature. See Section 34 20 05 – Prefabricated Enclosures, for further requirements.

D. Identify environmental factors that may affect equipment operations both before and after installation of the equipment, including shock and vibration. Environmental deficiencies uncovered during installation testing, on-line demonstration, or final tests may be cause for additional design adjustments and additional environmental testing by the Core Systems DBOM Contractor. The City shall retain the exclusive right to judge the environmental acceptability of the components before final acceptance.

2.12 ELECTROMAGNETIC AND ELECTROSTATIC SUSCEPTIBILITY

A. System equipment shall not be adversely affected by radiated or conducted electromagnetic or electrostatic interference from trains or fixed sites and other electric/electronic equipment on or near public transit areas including but not limited to the following: trains operating within the guideway, fixed site equipment, cellular telephones, mobile radios, incidental (spurious) radiation equipment, ignition noise, lighting fixture, electrical power system transients, vehicular systems, and electrostatic discharge.

B. Investigate all Electromagnetic and Electrostatic Susceptibility factors that may affect equipment operations both before and after installation of the equipment. Electromagnetic and Electrostatic Susceptibility deficiencies uncovered during installation testing, on-line demonstration, or final tests may be cause for additional design adjustments and additional testing by the Core Systems DBOM Contractor. The City shall retain the exclusive right to judge the acceptability of the components before final acceptance.

2.13 WIND, WEATHER AND ELEMENTS

A. All exterior equipment and any other potentially exposed units shall be designed and tested to operate continuously and reliably in varying conditions of humidity, rain, salt, dust, cleaning detergents, water spray, roadway chemicals, exhaust emissions, and other contaminants found in the transportation areas.

B. This means that appropriate rain/corrosion tightness testing shall be conducted for all transit equipment. All exterior components shall be designed and finished to resist adverse effects from solar radiation.

C. Provide all TES equipment designs, products, and installations complying with the data and criteria for Wind loads as stated in the HHCTCP Design Criteria Chapter 3 – Environmental and Chapter 9 – Structural, and Section 28 37 00 – Wind Speed Detection.
2.14 **ELECTRICAL POWER:**

A. All components shall be certified via testing to operate with normal outputs when the input voltage varies as much as plus or minus 10 percent.

2.15 **TRACTION POWER EQUIPMENT ANCHORING AND BRACING**

A. Seismic design for traction power equipment, including bracing and support of devices and anchoring of equipment, shall conform to the IBC requirements as stated in the Design Criteria Chapter 9 – Structural, and Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems.

B. Conform to Section 26 05 29 – Hangers and Supports for Electrical Systems.

2.16 **WAYSIDE SIGNAGE AND GRAPHICS**

A. Signage and graphics shall be provided for TES facilities in conformance with the RFP Plans, the requirements of the General Conditions, and Section 26 05 53 – Identification for Electrical Systems.

**PART 3 – EXECUTION**

3.01 **TESTING**

A. Submit compliance certificates for all test instruments, meters and equipment from a Nationally Recognized Testing Laboratory of calibration at intervals of not more than 6 months.

B. Factory and Field Testing shall be performed in accordance with the requirements of Section 34 20 80 – Traction Electrification System Testing.

C. See Technical Provision TP-02, “Verification, Testing and Acceptance” for further requirements.

3.02 **MANUALS**

A. Provide operating and maintenance manuals for all TES equipment. These manuals shall include all required information in accordance with the Technical Provision TP-03, “O&M Performance Requirements”.

3.03 **TRAINING**

A. Provide training in accordance with the Management Provisions of this Contract. Provide in service courses oriented toward providing City personnel with a thorough understanding of each TES equipment, providing system capabilities and comprehensive instruction.

B. In service and course training shall use As-Corrected plans including hands-on demonstration and practical training on the installed TPSS, GBS and other components of the TES. The in-service training shall include Theory and Operation of TES, how to place the substation into initial operation, making necessary adjustments while the equipment is in operation, shutting down the equipment, troubleshooting procedures, testing, adjusting, disassembling, and assembling sub-assemblies and components with a thorough understanding.
instruction in Safety/Emergency procedures. The results of the training shall be to have prepared and enabled the trainees to be competent qualified service technicians to operate, troubleshoot, and perform preventative electrical equipment maintenance and make repairs to maintain the equipment and systems. Training shall also include maintenance requirements of the physical facilities including exterior roof and paint finish maintenance.

C. All training courses shall be completed prior to the date of substantial completion.

D. Upon completion of the training instructions and courses, the personnel shall receive certification to operate and maintain the equipment.

E. Provide all special tools, equipment, training aids, and other materials required for the training of O&M personnel. The number of special tools and other training equipment shall be adequate for the number of participants attending the training courses.

F. Submit a detailed course outline to the City for review and approval. Furnish lists of course materials, training aids and equipment required, and names and qualifications of instructors proposed for the training.

G. The Contractor may use initial provisioned parts and/or test equipment provided under this Contract as training aids, for demonstration, and for practical exercises in adjusting, testing, disassembly, and assembly of equipment. Ensure that the parts and test equipment so used are repackaged and returned to the City’s parts storage in their original condition.

3.04 INITIAL PROVISIONING

A. Each complete component and assembly shall be provided with an itemized list of parts with quantities, order preference, and price that the Contractor recommends for 2 years of operation before restocking. The reference number for each item shall include the Contractor’s and the original manufacturer’s part numbers. See Technical Provision TP-03, “O&M Performance Requirements” for further requirements.

END OF SECTION
PART 1 – GENERAL

1.01 SUMMARY

A. Description:

1. The Work of this Section includes the requirements for the design, procurement, installation, and testing of the pre-engineered prefabricated enclosures for the Traction Power Substations (TPSS) and the Gap Breaker Station (GBS).

2. The Enclosure design contains all equipment as necessary to provide for the operation and control of Traction Electrification Systems - Substations equipment as indicated in the RFP Plans.

3. As a minimum, the TPSS and GBS equipment to be installed within and on the exterior of the enclosure shall include, but not be limited, to the following:

   a. Traction Equipment:
      1) AC Medium Voltage Switchgears (GBS Not Required)
      2) Transformer Rectifier Unit (GBS Not Required)
      3) Traction Rectifier Unit (GBS Not Required)
      4) DC Switchgear
      5) Negative Ground Switches
      6) DC Corrosion Control
      7) Breaker Test Stations
      8) External Enclosure Ground Connections

   b. Auxiliary Power Equipment:
      1) 125 V dc Batteries with Chargers
      2) AC and dc Distribution Panelboards
      3) Ground Test Stations
      4) Ground Bus
      5) Generator Receptacle
      6) Manual Transfer Switch

   c. Communication Control Equipment:
      1) LCD-Operators and Programmable Logic Controller/Annunciator Panel
      2) Remote/Control Selector Switch
      3) Transfer Trip Circuits
      4) Blue Light Stations/Emergency Trip Station
      5) Communication Interface Cabinet

   d. Miscellaneous:
      1) Fluorescent Lighting
      2) Convenience Outlets
      3) Fire Alarm Control Panel
4) Strobe Lights and Horn
5) Heating Ventilation Air Conditioning Units

B. Section Includes:
1. Enclosure Type
2. Product
3. Enclosure Shell
4. Doors and Removable Panels
5. Finishes
6. Insulation
7. Electrical Work
8. Ventilation
9. Fire Alarm Detection System
10. Fire Extinguishers
11. Intrusion Detection and Alarm System
12. Emergency Eyewash
13. Warning Signs
14. Spare Space
15. Supervising Control and Annunciation Requirements
16. Initial Provisioning

C. Related Sections:
1. Section 09 91 00 – Painting
2. Section 09 97 13 – Steel Coatings
3. Section 23 09 00 – Instrumentation and Control for HVAC
4. Section 23 33 00 – Air Duct Accessories
5. Section 23 81 00 – Decentralized Unitary HVAC Equipment
6. Section 26 05 00 – Common Work Results for Electrical
7. Section 26 05 29 – Hangers and Supports and Electrical Systems
8. Section 26 05 33 – Raceway and Boxes for Electrical Systems
9. Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems
10. Section 26 42 01 – Corrosion Control and Cathodic Protection
11. Section 26 51 00 – Interior Lighting
12. Section 27 30 01 – Communications Transmission System
13. Section 27 60 00 – SCADA System
14. Section 28 31 00 – Fire Alarm System
15. Section 34 20 01 – Traction Electrification – General Requirements
16. Section 34 20 10 – AC Switchgear
17. Section 34 20 18 – Traction Electrification System MSF Grounding Requirements
18. Section 34 20 19 – Traction Electrification System Grounding Requirements
19. Section 34 20 35 – Control and Annunciation
20. Section 34 20 40 – Emergency and Transfer Trip System
21. Section 34 20 50 – Miscellaneous Materials and Devices
22. Section 34 20 51 – Traction Electrification System Interface Requirements
23. Section 34 20 52 – Traction Electrification System MSF Interface Requirements
24. Section 34 20 70 – Traction Electrification System Interfaces
25. Section 34 20 80 – Traction Electrification System Testing

1.02 PRICE AND PAYMENT PROCEDURES
A. General: Separate measurement or payment will not be made for the Work required under this Section. All cost in connection with Work specified herein will be considered to be included with the related item of work in the General Conditions requirements, or incidental to the Work.

1.03 CODES, STANDARDS, AND RECOMMENDED PRACTICES
A. General: The TPSS equipment shall be designed, manufactured and tested in accordance with the latest editions (or replacements) of the following standards, codes, orders, and regulations, as applicable. Where reference standard or code has been revoked without replacement by the City, the referenced version shall still apply for the purpose of this Contract. Where any requirements of these Specifications differ from those of the applicable standards or codes, the requirements of these Specifications shall govern.

B. American National Standards Institute (ANSI):
   1. ANSI Z55.1 Gray Finishes for Industrial Apparatus and Equipment
   2. ANSI Z358.1 Emergency Shower and Eyewash Equipment

C. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):
   1. Handbook of Fundamentals

D. ASTM International (ASTM):
   1. ASTM A36 Structural Steel
   2. ASTM A446 Steel Sheet, Zinc-Coated, Structural Quality
   3. ASTM D229 Rigid Sheet and Plate Materials Used for Electrical Insulation
   4. ASTM D709 Polyester Glass-Metal Sheet Laminate / Laminated Thermosetting Materials

E. Hawaii OSHA Standards
F. Illuminating Engineering Society of North America (IES):
   1. RP-7 Practice for Industrial Lighting

G. Institute of Electrical and Electronics Engineers (IEEE):
   1. IEEE 693 Recommended Practices for Seismic Design of Substations

H. International Building Code (IBC)

I. National Fire Protection Association (NFPA):
   1. NFPA 10 Standard for Portable Fire Extinguishers
   2. NFPA 70 National Electrical Code
   3. NFPA 72 National Fire Alarm Code
   4. NFPA 70E Standard for Electrical Safety in the Workplace

J. Steel Structures Painting Council (SSPC):
   1. Procedure SP-6 Joint Surface Preparation Standard: Commercial Blast Cleaning

K. Underwriters Laboratories (UL):
   1. UL 154 Carbon-Dioxide Fire Extinguishers

L. Uniform Mechanical Code (UMC)

M. USA Department of Labor Federal Occupational Safety and Health Administration (OSHA) Standards

1.04 PERFORMANCE REQUIREMENTS

A. Provide a pre-engineered enclosure for the TPSS and GBS that meets the following design criteria:
   1. Design to include provisions for replacement of all large equipment, such as circuit breakers and the rectifier transformer.
   2. Construct of structural steel framework and sheet steel. It shall feature double-sided walls with thermal and acoustic insulation. The enclosure shall be rainproof, and shall meet applicable ANSI standards.
   3. Provide for emergency access to and egress from the substations in accordance with local Fire and Building Codes.
   4. Provide with emergency lighting and exit signs in accordance with local codes.
   5. The enclosure working space area shall be free of obstructions in front of the meters, service panels, and electric equipment for safe access to all electric equipment and metering. Working space shall be maintained, as prescribed by the installed equipment manufacturer requirements and code requirements. Aisle width shall allow for convenient removal of the draw-out ac and dc circuit breakers and as required by the National Electric Code. See Section 34 20 01 – Traction Electrification - General Requirements, for further requirements.
6. The enclosure interior and external paint finish shall be suitable for atmospheric conditions for air-induced corrosion and shall comply with the requirements of Section 09 97 13 – Steel Coatings.

7. Design for a life expectancy of 30 years.

8. The enclosure’s Fire Alarm System shall provide local and remote fire alarms, detector control loop trouble alarms, and shutdown of ventilation equipment on smoke or heat detection. Local Annunciation strobes and horn within enclosure shall be provided.

9. Provide accessible ground test stations, as indicated in the RFP Plans for measurement of the ground system.

10. A minimum of three 20 Amp GFI duplex convenience outlets shall be conveniently located around the interior walls of the substation. One outlet to be located near the switchgear and rectifier shall be separately circuited to permit use of a heavy-duty vacuum cleaner or up to 5-horsepower portable air compressor; another to be near the work table for work related devices for maintenance or service personnel to operate test equipment such as portable laptops or test meters; and another located outside in a weatherproof box on an exterior wall of the building shall be provided with outlet covers and tamper proof screws.

11. A Manual Transfer Switch within the interior of the enclosure and an externally mounted generator receptacle shall be provided to allow a portable generator to power the ac auxiliaries power panel, 125 V dc Battery Charger, and its dc distribution panel. The generator receptacle ampacity shall be adequately sized to allow continued operation of charger and loads should the batteries be out of service.

12. The Auxiliary low-voltage ac power for the enclosure shall be a 3-phase, 4-wire circuit at 120/208 V provided via the station service transformer supplied from the substation’s primary ac bus. A low-voltage ac distribution panel shall be used to provide power to various equipment such as air conditioning, interior and exterior lighting, battery charger, and convenience receptacles.

13. The design of the TES Corrosion Control shall incorporate provisions that mitigate stray currents and provide means of monitoring potential stray currents as indicated in the RFP Plans and as specified in Section 26 42 01 – Corrosion Control and Cathodic Protection. The corrosion control system shall be comprised of drainage panels, drainage cables, diodes, and associated raceways. The drainage panel shall comprise a minimum of four circuits. Each drainage cable connection point on the drainage bus shall be equipped with a single-pole disconnect switch, diode, current measuring shunt, and current limiting fuse, variable resistor, and ammeter.

14. Foundations are to be provided in accordance with Section 34 20 51 – Traction Electrification System Interface Requirements, by the MSFDB Contractor and the Guideway Contractors. The Core Systems Design–Build-Operate-Maintain (DBOM) Contractor shall coordinate with these contractors. Coordinate and provide all necessary parameters, including weights for the design and installation of these foundations to the Guideway and MSF DB Contractors.

15. Coordinate with the Guideway Contractor and MSFDB Contractor on the installation of stairs as necessary for entry into the enclosure. Provide all necessary data to these contractors to construct stairs for the construction of stairs.
as indicated in the RFP Plans and in Section 34 20 51 – Traction Electrification System Interface Requirements and Section 34 20 52 – Traction Electrification System MSF Interface Requirements.

16. Blue Light Stations with Emergency Trip Station (ETS) pushbuttons and voice communication shall be provided under Section 27 60 00 – SCADA System. The units shall be mounted on the enclosure exterior wall at the entrance doors of the enclosure. The Prefabricated enclosure manufacturer shall make provisions and provide raceways and cables within the enclosure to interconnect the ETS pushbutton and for the power requirements for the ETS/BLS station. See Section 34 20 40 – Emergency and Transfer Trip System. Make provisions for the installation of voice communication requirements as specified in Section 27 30 01 – Telephone Systems.

17. The dc Feeder and Cathode Breakers and ac to dc Rectifier Equipment shall be installed on a floor that is electrically insulated from the enclosure using coatings or materials suitable for this application.

18. Interior lighting shall be maintained at a lighting intensity of not less than 50-foot candles vertical on the faces of the equipment. Uniformity ratio shall not exceed 3 to 1.

19. Interior lighting shall be located so as not to create a glare on the front of the multifunction relays, LCD screen, devices, and meters. Locations of lighting fixtures shall be coordinated to avoid interference with overhead raceways or other major wiring and shall not be directly above switchgear, rectifiers, or transformers. The interior lighting shall be controlled by surface-mounted 3-way or 4-way switches located each entry door. See Section 26 51 00 – Interior Lighting, for further requirements. Lighting shall conform to IES-RP-7, Standard Practice for Industrial Lighting.

20. Exterior weatherproof lighting consisting of a wall mounted area lighting fixture above each door. The lighting fixture shall provide a low glare, downward, and outward light distribution resulting in a minimum illumination level of 2 foot-candles at ground level in front of the door. The exterior lighting shall be on a separate circuit, and shall be controlled by a switch with three positions as follows: ON, OFF, and AUTO. In the AUTO position, the exterior lighting shall be controlled by a photoelectric cell.

21. Provide a climate control system, to maintain a target indoor aisle temperature of 77 degrees Fahrenheit and humidity not exceeding 50 percent, at the extremes of outside temperature and humidity in accordance with Design Criteria Chapter 3 – Environmental. Maximum interior temperature shall be 104 degrees Fahrenheit with one unit out of service. Minimum interior temperature shall be 60 degrees Fahrenheit. A positive pressure of 0.1-inch water column shall be provided at all times. Ventilation system shall meet requirements of the Uniform Mechanical Code.

22. The Prefabricated Enclosure equipment including HVAC units shall comply with the noise and sound pressure level as described in Article 2.06B herein.

23. Refer to Section 26 05 29 – Hangers and Supports for Electrical Systems and Section 26 05 33 – Raceway and Boxes for Electrical Systems, for further requirements of the installation of products within the enclosure.
24. Provide key interlock between the auxiliary transformer drawout type fuse and the main circuit breaker located in the 208/120 Vac panel. See Section 34 20 10 – AC Switchgear, and the RFP Plans for further requirements. Provide appropriately sized transformer and ac cabinet to meet the electrical loads of the building.

25. The Prefabricated Enclosure and its components shall meet seismic design requirements in accordance with Design Criteria Chapter 9 – Structural, and Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems.

26. See Section 34 20 01– Traction Electrification - General Requirements, for environmental, electromagnetic susceptibilities, shock, vibration, and weather elements criteria.

27. Provide coordination with the utility requirements for the GBS meter socket, disconnect switch and instrument transformer cabinet as indicated in RFP Plans. Provide supports and equipment arrangement for the installation of these externally mounted wall cabinets as indicated in the RFP Plans.

1.05 SUBMITTALS

A. General: Refer to General Conditions requirements for Submittal Procedures, and for Shop Drawings, Product Data, and Samples requirements and procedures.

B. For submittal requirements, submit all data, Design Plans, procedures and samples in accordance with Section 34 20 01 – Traction Electrification - General Requirements, including, but not limited to the following:

1. Manufacturer’s descriptive literature, catalog data, and information.
2. Layout arrangement and detailed shop drawings of the enclosure with installed accessories and substation equipment.
3. Certificates of Compliance for specified enclosure materials and performance.
4. Structural analysis calculations for roof, wind, and seismic loadings. Calculations shall be certified by a structural engineer registered in the State of Hawaii.
5. Certified test results of thermal, electrical, and acoustical insulation.
6. Construction drawings including:
   a. Foundation Requirements: including all special requirements to support the enclosure
   b. Enclosure base anchorage locations, floor loading, uplift and horizontal wind and seismic loadings on anchorage
   c. Stair Requirements: including all special requirements to enter or egress from the enclosure
   d. Raceway, conduit, cable trays, and ductwork arrangements
   e. Enclosure grounding details
7. Lighting, ventilating, fire detection, and intrusion detection, equipment wiring, and schematic diagrams.
8. Operations and Maintenance Manuals: Operation and Maintenance Manuals for all Traction Power equipment and materials shall conform to the General Conditions requirements.

9. Training Manuals and Equipment: Training manuals and equipment shall conform to the requirements of the General Conditions requirements.

1.06 QUALITY ASSURANCE

A. General: Refer to General Conditions requirements for quality assurance requirements and procedures.

B. Comply with all applicable Federal, State, and Local Laws, Regulations, and Codes including those referenced in Article 1.03.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Equipment shall be weatherproofed for shipment. Connection openings shall be closed to prevent entrance of foreign material during shipment and storage.

B. Ship each item of equipment and materials securely wrapped, packaged, and labeled for safe handling in shipment and to avoid damage.

C. Store enclosure and materials in secure and dry storage facility.

D. Provide loose components within enclosure securely tied down during shipment.

E. Equipment shall be handled and stored in conformance with manufacturer’s instructions. One copy of these instructions shall be included with the equipment at time of shipment.

F. Provide, as determined by the City, temporary power to the enclosure during storage for operating the ventilation system, lighting and 125 V dc battery system to prevent moisture, contamination, and battery failures. Provide heaters where necessary to maintain dry area as required.

G. Shipping splits are to be kept to a minimum considering the following restrictions:
   1. Site Limitations.
   2. Transportation Considerations: Shipping splits when required due to transportation restrictions, shall require, as a minimum, each open area to be sealed with 2-inch thick wooden framing and a complete plywood cover for temporary protection during transportation and setting. Seams in plywood shall be liberally caulked at the exterior.

1.08 WARRANTY

A. The Core Systems DBOM Contractor suppliers shall warrant that their products are free from defects. Warranty shall conform to the requirements of the General Conditions requirements.

PART 2 – PRODUCTS

2.01 ENCLOSURE TYPE

A. Enclosure shall be totally integrated weatherproof unit to house the indicated TPSS equipment. The enclosure shall provide a dry, condensation-free, stable internal ambient temperature environment. Enclosure shall be of Type II – B noncombustible
construction and have a Group F-1 occupancy classification in accordance with IBC requirements and meet NFPA 101 Code requirements.

### 2.02 PRODUCT

**A. Structural Loadings:** Engineer the enclosure to withstand vertical line roof loading, wind loadings, and seismic loading as described in the design requirements in accordance with Design Criteria Chapter 9 – Structural. Design the enclosure to accept the stresses caused during transportation without causing a serious damage to the enclosures structural components. Doors, walls, and roof panels shall be reinforced by braces, stiffeners, and/or structural members to provide a rigid module. Deflection under described loadings shall not exceed 1/4-inch per 10 feet span. Supports, fasteners, structural insulators, and anchorages shall resist vibration and seismic loadings as specified in Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems, and shall be designed in accordance with recommendations in IEEE 693. The roof shall be slopped at a minimum 2 percent incline.

**B. Configuration:** Overall substation enclosure dimensions shall not exceed those indicated on the RFP Plans. Interior working spaces and clearance shall comply with NFPA 70, Article 110, and NFPA 70 E both in size and in arrangement. For mainline substations, the Contractor may submit smaller dimensions for approval by the City at its discretion, provided that adequate clearance of not less than 2'-6" is maintained between fully withdrawn ac and dc circuit breakers and other stationary equipment or building walls.

**C. Ventilation:**

1. HVAC system design, shall comply with the Design Criteria Chapter 19 – Facilities Mechanical and ASHRAE standards.
2. Cooling shall be based on substation operating at 150 percent of rated capacity.

### 2.03 ENCLOSURE SHELL

**A.** The enclosure shell, including doors, shall be constructed of not less than No. 14 gauge sheet steel mounted on a structural steel base frame to permit jacking, rolling, and skidding. Removable lifting lugs shall be provided on the base to facilitate a four-point lift on each fully equipped substation assembly or modules. Structural steel shall have a minimum allowable yield as specified in ASTM A36. Roof and wall panel steel shall have a minimum allowable yield as specified in ASTM A446 for Grade A. Ground pads shall be welded to enclosure base at four locations to match ground grid loose coil locations as indicated in the RFP Plans. The roof shall be sloped to prevent water from puddling. Minimum slope of roof shall be at a minimum 2 percent incline. Roof shall have a solar reflective index (SRI) of 78. See Design Criteria Chapter 26 – Sustainability, for further requirements.

### 2.04 DOORS AND REMOVABLE PANELS

**A.** The substation shall have two entry egress access locations doors located, as indicated in the RFP Plans. The double door shall be the main entry door, sized as required to permit removal of substation equipment. Doors shall be equipped with three-point crash-bar safety latches to permit opening from within under all conditions. The latches shall have tamper-proof locks. Entry doors shall be keyed alike. To prevent entry of unauthorized persons, a unique key shall be provided for each substation with provision for re-keying by the City after the deenergization of the substation enclosure.
Door closers shall be provided and doorstops furnished to hold the door in the open position.

B. Hinged exterior access doors with hinges, three-point latches, and padlocking lugs shall be provided behind equipment requiring access for cable makeup or maintenance.

C. Bolted panels with tamper-resistant fasteners shall be furnished to permit removal of Rectifier Transformers through side of enclosure.

D. Equipment access doors or removable panels shall be provided to allow rear access from the outside to the dc feeder circuit breakers and utility metering compartment, for ease of installation and maintenance.

2.05 FINISHES

A. Exterior metal surfaces, excluding the floor bottom - galvanized and prepared for finish painting with a vinyl wash primer. Apply coating of rust inhibitive vinyl primer and at least two finish coats of high solids vinyl. Minimum dry film thickness (DFT) shall be 6 mils. Color shall be dark green, see Design Criteria Chapter 13 – Traction Electrification.

B. Exterior floor bottom and base framing - steel shall be commercial blast cleaned in accordance with SSPC Procedure SP-6 and then be prime coated with 3 mil minimum DFT of inorganic zinc such as Carbo Zinc II as manufactured by Carboline Company, Valspar MZ-7 as manufactured by the Valspar Corporation or approved equal. After inorganic zinc has cured as noted in manufacturer’s recommendations, apply top coat(s) of minimum 16 mils DFT of Coal Tar Epoxy such as Carbomastic No. 14 as manufactured by Carboline Company, Coal Tar Epoxy No. 64-J-3 as manufactured by Valspar Corporation or approved equal. Materials shall be applied and cured in accordance with manufacturer’s recommendations.

C. Interior metal surfaces excluding the floor and insulated areas: Apply one coat of rust inhibitive vinyl primer and at least one finish coat of high solids vinyl. Minimum DFT shall be 2 mils. Color shall be white.

D. Interior floor excluding insulated areas: Apply one coat of alkyd primer and at least two coats of alkyd resin industrial enamel for a DFT of 6 mils. Color shall be medium light gray No. 49 in accordance with ANSI Z55.1.

E. Finishes shall comply with the technical design requirements in accordance with Design Criteria Chapter 10 – Architectural, Design Criteria Chapter 13 – Traction Electrification, Section 09 91 00 – Painting, and Section 09 97 13 – Steel Coatings.

2.06 INSULATION

A. Equipment Electrical Insulation:

1. Furnish and install all equipment insulation, as required.

2. Samples of the materials, their physical and electrical properties, and proposed methods of installation shall be submitted for approval.

3. The metal enclosures grounding system for the dc switchgear cubicle and rectifier cubicle shall be grounded by either a High or Low grounding resistance system.

4. The insulating materials, when exposed to flames or electrical arcing, shall not give off toxic gases or products of combustion, which are harmful to personnel or to the surrounding equipment or which will result in electrical arcing.
5. The minimum clearance between ground equipment and solidly grounded equipment shall be 8 feet, unless indicated otherwise.

6. Where clearance from any parts of High Resistance grounded equipment to walls, columns, doors, equipment or any grounded object is less than 6 feet, the walls, columns, doors, equipment or grounded object shall be insulated to a height of 8 feet with an insulation sheet of plastic-type material rated at 1,500 volts dc minimum.

7. No gaps shall exist between electrical wall insulation and the floor or between adjacent insulation sheets. No non-insulated fittings or hardware shall protrude through or be unprotected by insulation.

8. Wall insulation protecting exposed structural wall sections shall extend at least 6 feet beyond the limits of the high-resistance ground equipment.

9. Floor insulation for High Resistance grounded equipment shall cover the entire floor.

10. Glastic-type insulation shall be provided between the rectifier transformer ac cubicle and the negative dc cubicle.

11. Provide insulation materials conforming to ASTM D229 and D709 standards.

B. Acoustical Insulation: The maximum permitted continuous sound pressure level produced by the substation, shall be as defined in Section 34 20 01 – Traction Electrification - General Requirements, and shall comply with the design requirements in accordance with Design Criteria Chapter 3 – Environmental, whichever is more stringent.

2.07 ELECTRICAL WORK

A. Products shall comply with Section 26 05 00 – Common Work Results for Electrical Requirements and Section 34 20 50 – Miscellaneous Materials and Devices.

B. AC Distribution Panelboard: Provide distribution panelboards, three-phase, 4-wire for loads as indicated, plus 20 percent spare, 1-pole circuit breakers.

C. DC Distribution Panelboard: Provide distribution panelboards, loads as indicated, plus 20 percent spare 1-pole circuit breakers.

D. Distribution Transformer, 12.47kV/208/120V (or 11.5kV/208/120V as indicated in RFP Plans) Class: Provide dry type transformers, three-phase, 208Y/120 V, with kVA ratings as required to support the calculated load. Transformer shall be installed within ac Auxiliary cubicle. See Section 34 20 10 – AC Switchgear, for further requirements of the ac Switchgear and the ac Cabinet main breaker.

E. Manual Transfer Switch: The units mechanical and electrical construction features shall comply with the requirements of Section 26 36 23 – Automatic Transfer Switches, without automatic features.

F. Generator Receptacle: Conform to Section 34 20 05 – Prefabricated Enclosures, for receptacle requirements.

G. Convenience Outlets: Provide an interior 20 Amp, 120 V, GFI duplex outlet at each end of the maintenance and operation walkways.
H. Lighting:
   1. Fluorescent lighting chain-suspended at nine feet above finished floor shall be
      provided in each TPSS and GBS:
         a. Fixtures shall be industrial reflector type with 40-watt rapid start, cool-white
            lamps.
         b. The average maintained lighting intensity shall not be less than 50-foot-
            candles at floor level. Uniformity ratio shall not exceed three to one.
         c. The interior lighting shall be controlled by surface-mounted 3-way or 4-way
            switches of specification grade, located near each entry door.
         d. Where fluorescent lighting is installed, provide protective shatterproof tubes
            if lens covers are not used.
   2. Provide interior emergency lighting with 2-hour back up battery and local test
      pushbutton. Indoor lighting shall be provided using fluorescent fixtures with
      rapid start, cool-white lamps.
   3. Provide exterior lighting controlled by a photocell. The fixture shall be UL-listed
      for wet locations, and shall be equipped with minimum 70-watt high-pressure
      sodium lamp and internal photoelectric control.
   4. Provide power for exterior blue lights for emergency trip stations in accordance
      with Section 27 30 01 – Telephone Systems.
   5. Amber alarm indication light at exterior of building for any alarm that has not
      been acknowledged within an adjustable period of maximum 10 minutes.

I. Wiring: Provide required internal wiring for substation equipment interconnections and
   enclosure interior electrical work. Provide wire in conformance with Section 34 20 50
   – Miscellaneous Materials and Devices.

J. Conduit and Cable Trays: Provide conduit, cable trays, supports, junction boxes, and
   related hardware. See Section 26 05 29 – Hangers and Supports for Electrical Systems
   and Section 26 05 33 – Raceway and Boxes for Electrical Systems for further
   requirements. Provide wire in conformance with Technical Provision Section 34 20 50
   – Miscellaneous Materials and Devices.

2.08 VENTILATION

A. HVAC units shall be vertical wall mounted type flush mounted with the outside wall of
   the substation. See Section 23 81 00 – Decentralized Unitary HVAC Equipment, for
   further requirements of the HVAC equipment.

B. Furnish and install controls that will operate HVAC units in a lead/lag manner with
   lead unit alternating every 24 hours. Lag unit will operate based on temperature or
   relative humidity level. Lead unit will run continuously to provide positive pressure in
   space.

C. Furnish and install pressure relief dampers as specified in Section 23 33 00 – Air Duct
   Accessories.

D. Furnish and install a flow switch at the pressure relief damper. No flow shall switch
   off the battery charger.

E. Provide thermostat, high temperature alarm, and humidistat as specified in Section
   23 09 00 – Instrumentation and Control Devices for HVAC.
F. The following alarms shall be transmitted to Central Control:
   1. Unit not operating
   2. No airflow
   3. Filter pressure high
   4. Space temperature high

2.09 FIRE ALARM AND DETECTION SYSTEM

A. Fire Alarm System:
   1. Provide a proprietary fire detection signaling system within each substation enclosure in accordance with NFPA 72.
   2. The system shall be monitored for the integrity of the interconnecting conductors and shall be provided for signaling line circuits of class A style 6 as defined by NFPA 72 performance.
   3. Fire alarm control panel (FACP) shall include means for testing and monitoring the system, and shall transmit the designated trouble signals and fire alarm annunciation. The FACP control unit shall be equipped with devices for shutdown of ventilating equipment upon fire alarm detection.
   4. Summary trouble signal and fire alarm annunciation shall be wired to the PLC inputs within the TPSS and GBS by a shielded wire circuit. The trouble alarm shall be initiated by but not limited to system trouble, earth fault, battery fault, and charger fault and power source failure. A separate power alarm shall also be provided for remote indication including a separate remote indication for FACP reset operation with separate indication alarm on the panel face. See the RFP Plans for further requirements.

B. Fire Detection System:
   1. Provide smoke sensing fire detectors in accordance with Uniform Fire Code (UFC) and NFPA 72. Establish location and spacing of detectors within the enclosure in conformance to Americans with Disabilities Act recommendations
   2. Smoke detector shall be UL-listed photoelectric type. Sensitivity shall be adjusted.

C. Fire Annunciation:
   1. Strobes shall be addressable and shall be installed within the enclosure. Strobes shall have candela rating as required per NFPA 72 requirements.
   2. Provide and install horns within the enclosure and in accordance with NFPA 72 requirements.

D. Fire Alarm System Power Source:
   1. The 24 V dc power panel within the TPSS and GBS shall serve as the main source of power to the system and serve equipment essential to operation of the fire alarm system. The dedicated branch circuit from the 24 V dc power panel shall be clearly marked as “FIRE ALARM CIRCUIT CONTROL”. The Power supplies shall be monitored Class A.
   2. The Power supply for the Fire Alarm Control Panel shall be integral to the FACP and shall provide all control panels and peripheral device power needs.

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secondary source to the FACP shall be capable of providing at least 24 hours of backup power with the ability to sustain 5 minutes in alarm at the end of the backup period.

3. If batteries are chosen as the secondary source, they shall have sufficient capacity and shall be completely maintenance free without the need for fluid level checks, refilling, spills, and leakage.

4. Provide a separate power alarm for trouble within the FACP with separate indication alarm on the panel face. This alarm shall also be transmitted as one of the initiators of the fire system trouble alarms.

E. Refer to Section 28 31 00 – Fire Alarm System and Design Criteria Chapter 21 – Fire and Intrusion Alarm Systems, for further requirements.

2.10 FIRE EXTINGUISHERS

A. Two portable type fire extinguishers shall be included in each substation. Each extinguisher shall be located inside and adjacent to each of the two exit doors. Fire extinguishers shall be portable carbon dioxide (CO₂) type, in accordance with NFPA 10 and UL 154. Wall mounted attachments shall be installed on interior of enclosure next to door to hang the Fire Extinguishers.

2.11 INTRUSION DETECTION AND ALARM SYSTEM

A. Provide an electro-mechanical intrusion detection device on each entry door and hinged equipment access pane. Device shall be actuated upon opening of the door by any means with connections to be provided to designated terminal blocks in the PLC/Annunciator panel. See Section 34 20 35 – Control and Annunciation System, Design Criteria Chapter 21 – Fire and Intrusion Alarm Systems, and the RFP Plans for further requirements.

2.12 EMERGENCY EYEWASH

A. Provide a portable eyewash unit with twin spray heads, 10-gallon stainless steel tank, automatic pressure control, push-to-operate valve, and pressure gauge. Product shall be in conformance with Hawaii OSHA Industrial Safety Orders and ANSI Z358.1.

2.13 WARNING SIGNS

A. Provide warning signs to be installed on the exterior of entry doors and hinged access panels and those areas where maintenance personnel will be exposed to nominal 12kV and 775V dc. Warning signs shall be made of the materials with lettering and installation as specified in Section 34 20 01 – Traction Electrification - General Requirements, Section 26 05 53 – Identification for Electrical Systems, and as indicated in the RFP Plans.

B. Provide the following warning signs in high contrast reflective 2 inch to 3 inch lettering permanently mounted on name plates with screws on the inside of all breaker cubicles “Caution Shock Hazard – Various components may have retained residual operating voltages within this Breaker Cubical” and “Bus Bar maybe hot even if breaker is not in the Breaker Cubical.”

2.14 SPARE SPACE

A. Spare space, as indicated, shall be provided for installation of equipment of the following type:
1. Telephones as required in conformance with Section 27 30 01 – Telephone Systems.

2. A cabinet for small spare parts, tools, safety equipment, operating and maintenance manuals, and schematics.

3. A table for working and to read the plans and manuals and log book preparation.

4. Communications Interface Cabinet (Fiber Distribution Panel, SCADA Ethernet managed edge switch, Gateway Remote Terminal Unit (R.T.U.)) as indicated on the RFP Plans.

2.15 SUPERVISORY CONTROL AND ANNUNCIATION REQUIREMENTS

A. Supervisory control and annunciation circuits shall be provided for the Prefabricated Enclosure as described in accordance with the Division 34 Technical Provisions and as indicated in the RFP Plans.

2.16 INITIAL PROVISIONING

A. Provide a recommended list of parts. Provide 5 percent of exterior entry doors, 2 gallons of exterior and interior coating materials, 5 percent of exterior removal panels to cover the ac and dc Breaker, Cubicles, and the other Traction Power Equipment.

B. Each complete component and assembly shall be provided with an itemized list of parts with quantities, order preference, and price that the Contractor recommends for 2 years of operation before restocking. The reference number for each item shall include the Contractor’s and the original manufacturer’s part numbers. See Technical Provision TP-03, “O&M Performance Requirements” for further requirements.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Factory Shop Installation:
   1. Construct each enclosure, complete.
   2. Install and wire substation equipment specified to be accommodated within each substation enclosure. Mount components in accordance with the manufacturer’s instructions and reviewed shop drawings.
   3. Provide basic electrical materials in accordance with Section 26 05 00 – Common Work Results for Electrical, and the City reviewed shop drawings.
   4. Verification and testing of each complete assembled fabricated enclosure shall comply with the General Conditions requirements.

B. Field Installation:
   1. Transport to site from storage facility:
      a. Prepare complete substation enclosures for transport to site by securing or removal of all loose items.
      b. Remove and separately package all interior and exterior components that are likely to be damaged in transport due to vibration, lifting, or bumping.
      c. Use approved spreader bar for lifting so as not to damage form, fit, or finish of equipment.
d. Utilize the services of an experienced and fully bonded rigging contractor to perform all lifting and transport of the prefabricated enclosure.

2. Rigging:
   a. Prepare complete substation enclosures for transport to site by securing or removal of all loose items.
   b. Submit for the review and approval thereof, sketches and data defining erection, demolition, or other hoisting operations used in support of construction near tracks. At City’s requests, submit information, data, and sketches for the safe use of equipment. This includes, but is not limited to the following:
      1) Plan view showing locations of cranes, operating radii with delivery or disposal locations shown.
      2) Crane rating sheets showing cranes to be adequate for the lift. Crane and boom nomenclature to be indicated.

3. Field Preparation:
   a. Verify the foundation and anchor bolt locations and install in accordance with the approved design before installation of the enclosure. Waterproof, non-hardening sealing compound shall be used between the foundation and enclosure base perimeter.
   b. Grounding connections shall be installed in accordance with the approved construction shop drawings and as indicated in Section 34 20 19 – Traction Electrification System Grounding Requirements and Section 34 20 18 – Traction Electrification System MSF Grounding Requirements.
   c. Install the enclosure on the foundation level and plumb.
   d. Coordinate enclosure design and installation with foundation pier and entrance stair installation. Contractor will be responsible for the matching of enclosure anchor locations with piers and the level mating of door stairs with as-installed enclosure doorways.
   e. The installed prefabricated enclosure shall be made ready for energization by connecting all, raceways and circuits between shipping split sections and all control circuits between ac and dc switchgear, transformers, and equipment inside the prefabricated enclosure. See Section 34 20 70 – Traction Electrification System Interfaces.
   f. Lighting, HVAC, fire detection, intrusion detection, and eye wash components shall be test operated for conformance with factory shop test results. Test as specified in Section 34 20 80 – Traction Electrification System Testing.
   g. Before traction power facilities are accepted by the City, building and floors shall be cleaned, repaired, and re-painted as required to present the appearance of a new installation.

END OF SECTION
SECTION 34 20 10  
AC SWITCHGEAR

PART 1 – GENERAL

1.01 SUMMARY

A. Description: The Work of this Section includes the design, procurement, and installation of medium-voltage, metal-clad indoor, alternating current ac power switchgear assemblies. The switchgear assemblies will receive power service from utility company underground service feeders at medium-voltage, 3-phase, 4-wire, and will control power supply to the Traction Power Substation (TPSS) Rectifier Transformer for powering the ac-to-dc conversion assemblies, and auxiliary power distribution transformers, as indicated in the RFP Plans.

B. Section Includes:
   1. AC Switchgear
   2. Medium-Voltage AC Circuit Breakers
   3. Auxiliary Transformer Compartment
   4. Surge Arresters
   5. Relays
   6. Lockout Relays
   7. Instrument Transformers
   8. Supervisory Control and Annunciation Requirements
   9. Switchgear Maintenance Accessories
   10. Initial Provisioning

C. Related Sections:
   1. Section 26 05 73 – Overcurrent Protective Device Coordination Study
   2. Section 34 20 01 – Traction Electrification - General Requirements
   3. Section 34 20 05 – Prefabricated Enclosures
   4. Section 34 20 35 – Control and Annunciation System
   5. Section 34 20 45 – DC Control Power System
   6. Section 34 20 50 – Miscellaneous Materials and Devices
   7. Section 34 20 60 – Traction Power Cables
   8. Section 34 20 80 – Traction Electrification System Testing

1.02 PRICE AND PAYMENT PROCEDURES

A. General: Separate measurement or payment will not be made for the Work required under this Section. All cost in connection with Work specified herein will be considered to be included with the related item of work in the General Conditions requirements, or incidental to the Work.
1.03 CODES, STANDARDS, AND RECOMMENDED PRACTICES

A. American National Standards Institute (ANSI):

1. ANSI C2 National Electrical Safety Code (NESC)
2. ANSI C29.1 Test Methods for Electrical Insulators
3. ANSI C37.01 Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
4. ANSI C37.04 Rating Structure for AC High-Voltage Circuit Breakers
5. ANSI C37.11 Requirements for Electrical Control for AC High-Voltage Circuit Breakers
6. ANSI C37.20.2 Standard for Metal-Clad and Station-Type Cubicle Switchgear
7. ANSI C37.20.3 Standard for Metal-Enclosed Interrupter Switchgear
8. ANSI C37.30 Definitions and Requirements for High-Voltage Air Switches, Insulators, and Bus Supports
9. ANSI C37.31 Indoor Apparatus Insulators
10. ANSI C37.32 Schedules of Preferred Ratings, Manufacturing Specifications, and Application Guide for High-Voltage Air Switches
11. ANSI C37.33 Rated Control Voltage and Their Ranges for High-Voltage Air Switches
12. ANSI C37.34 Test Code for High-Voltage Air Switches
13. ANSI C37.41 Design Tests for Power Fuses
14. ANSI C37.46 Specifications for Power Fuse Disconnecting Switches
15. ANSI C37.55 Conformance Testing of Metal-Clad Switchgear
16. ANSI C39.5 Safety Requirements for Electrical and Electronics Instrumentation
17. ANSI C57.13 Requirements for Instrument Transformers
18. ANSI C62 Surge Protection Standards Collection
19. ANSI Z55.1 Gray Finishes for Industrial Apparatus and Equipment

B. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE 141 Recommended Practice for Electric Power Distribution for Industrial Plants
2. IEEE 693 Recommended Practices for Seismic Design of Substations
3. IEEE C37.23 Metal Enclosed Bus and Calculating Losses in Isolated Phase Bus
4. IEEE C37.90 Relays and Relay Systems Associates with Electric Power Apparatus
5. IEEE C37.91 Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems

C. National Electrical Manufacturers Association (NEMA):
   1. NEMA BU 1 Busways
   2. NEMA CC 1 Power Connections
   3. NEMA EI 21.1 Instrument Transformers
   4. NEMA FU 1 Low-Voltage Cartridge Fuses
   5. NEMA ICS 1 General Standards for Industrial Controls and Systems
   6. NEMA ICS 2 Industrial Control Devices, Controllers and Assemblies
   7. NEMA ICS 6 Enclosures for Industrial Controls and Systems
   8. NEMA SG 4 AC High-Voltage Circuit Breakers
   9. NEMA SG 5 Power Switchgear Assemblies
  10. NEMA SG 6 Power Switching Equipment

D. National Fire Protection Agency (NFPA):

E. Underwriters Laboratories (UL):
   1. UL 50 Enclosures for Electrical Equipment
   2. UL 855 Safety Busways and Associated Fittings
   3. UL 870 Wireway, Auxiliary Gutters and Associated Fittings

1.04 PERFORMANCE REQUIREMENTS
A. The integrated lineup of metal-clad switchgear assemblies and utility company service metering panels for the incoming cable shall be adequately designed, sized, and coordinated with the other components to be installed within the Prefabricated Enclosure as indicated on the RFP Plans.

B. It is the responsibility of the Core Systems Design-Build-Operate-Maintain (DBOM) Contractor to provide equipment and coordinate with the Guideway Contractor and MSFDB Contractors that a complete and operable system is procured and installed to meet the intent and operation of these Specifications and as indicated in the RFP Plans.

C. Protective Relay devices shall be installed in their cases prior to final inspection and shipment.

D. Circuit breaker tripping shall not be affected by the position of the TPSS and GBS master Remote/Local Selector switch specified in Section 34 20 35 – Control and Annunciation System.

E. Refer to Section 34 20 01 – Traction Electrification - General Requirements, for abbreviations, definitions of the TES equipment, device requirements, and further requirements.

1.05 SUBMITTALS
A. General: Refer to General Condition requirements for Submittal Procedures, and for Shop Drawings, Product Data, and Samples requirements and procedures.
B. Submit all data, design plans, procedures and samples in accordance with Section 34 20 01 – Traction Electrification - General Requirements, including, but not limited to the following:

1. Manufacturer’s descriptions, catalog data and information, including model numbers or item identification.
2. Manufacturer’s general arrangement and detail drawings for each type of switchgear assembly and prime components.
3. Manufacturer’s schematic wiring and interconnection diagrams.
4. Protection devices, coordination curves, and setting data.
5. Operation and maintenance manual, including spare parts list.

1.06 QUALITY ASSURANCE

A. General: Refer to General Conditions requirements for quality assurance requirements and procedures.
B. Comply with all applicable Federal, State, and Local Laws, Regulations, and Codes including those referenced in Article 1.03.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As the ac switchgear is installed within the Prefabricated Enclosure, coordinate the delivery, storage, and handling of the ac switchgear with the requirements as described in Section 34 20 05 – Prefabricated Enclosures.

1.08 WARRANTY

A. The Core Systems DBOM Contractor suppliers shall warrant that their products are free from defects. Warranty shall conform to the requirements of the General Conditions requirements.

PART 2 – PRODUCTS

2.01 AC SWITCHGEAR

A. Type:

1. The power switchgear assemblies shall comply with the requirements given in ANSI C37.20.2, ANSI C62, NEMA SG 5, IEEE 141, IEEE 693 and the utility company electrical service requirements.
2. Assemblies shall be comprised of an integrated lineup of metal-clad switchgear, metal enclosed fused integrated stationery auxiliary transformer, and utility company service metering panels for incoming cable enclosures. Each assembly shall incorporate draw-out type circuit breakers, draw out power fuse truck, surge
arresters, bus and connections, instrument transformers, meters, relays, control wiring, and accessory devices, as indicated on the RFP Plans.

B. Ratings: The switchgear assemblies shall have the following:

1. Nominal Operating Voltage, kV, rms: 12.47 or 11.5 kV rms, as indicated on the RFP Plans.

2. Rated Maximum Operating Voltage, kV, rms: 15

3. Rated Frequency, Hz: 60

4. Rated Insulation Level
   a. Power Frequency Withstand, kV, rms: 36
   b. Impulse Withstand (1.2 x 5 microseconds), kV Crest: 95

5. Rated Bus Continuous Current, Amps: 1,200

6. Rated Momentary Current Withstand, kA, rms, minimum: 39

C. Construction:

1. Stationary Structure:
   a. Each switchgear lineup shall be comprised of the required number of metal-clad and metal-enclosed equipment sections, assembled together to form a rigid self-supporting structure with barriers of painted steel between units.
   b. Each metal-clad section shall consist of the required number of structures, segregated by grounded metal barriers into separate compartments for circuit breakers, instrument transformers, main bus, instrument and relays, and incoming service connections. The sections shall comply with NEMA ICS 1, ICS 2, and ICS 6 standards.
   c. Each metal-enclosed section shall consist of the required number of structures, providing complete front accessibility to the circuit breaker, drawout power fuses, instrument transformers, and bus duct or feeder cable connections. The sections shall comply with UL 50, 855, and 870 and IEEE C37.23 standards.
   d. Feeder cable terminations shall comply with Section 34 20 60 – Traction Power Cables. Utility service incoming cables will be terminated by the utility, complying with NFPA 101 requirements.
   e. For device height limitations, refer to Section 34 20 01 – Traction Electrification - General Requirements.

2. Doors and Panels:
   a. Each circuit breaker, potential transformer, and fused auxiliary transformer compartment shall be provided with a formed hinged front door with handle and three-point latch. Each door shall be furnished with a stop to hold the door in the open position. Circuit breaker and potential transformer equipment doors shall not hinder withdrawal of the element from the compartment when the door is open and doorstop set. Auxiliary transformer compartment door shall have shatterproof inspection windows to permit observation of truck, contact positions, and power fuse operation indicators.
   b. Relays, instruments, meters, and secondary control devices shall be mounted on formed front-hinged panels and provided with handle, lockable latch, and stop to hold panel in the open position. Equipment mounted on the panel
shall be isolated by grounded metal barriers from all primary circuit elements.

c. Access to main bus, incoming service connections, bus duct or feeder cable terminations, current transformers, bushings, and other stationary devices shall be provided with hinged, bolted panels.

3. Circuit Breaker Compartment:
   a. Circuit breaker compartment shall be designed to house draw-out type circuit breaker element. Welded guide rails for positioning the circuit breaker shall be provided as an integral part of the compartment.
   b. Automatic shutters shall be provided in the compartment to prevent accidental contact with the stationary primary disconnecting contacts when the circuit breaker element is withdrawn from the CONNECTED position.
   c. A ground bus shall extend into the compartment to automatically ground the circuit breaker frame in the CONNECTED and TEST positions. The ground bus shall maintain the circuit breaker frame grounded during the transition between the three positions.
   d. Means shall be provided for positively holding the circuit breaker element in place when it is in the CONNECTED or TEST/DISCONNECTED positions within the compartment. Mechanical interlocks shall also prevent incorrect movement of a closed circuit breaker to or from the designated positions within the compartment, and prevent electrical closing of the circuit breaker within the compartment unless it is in the CONNECTED or TEST positions. Provisions shall be made for padlocking the circuit breaker element in the TEST/DISCONNECTED position with a 1/4-inch diameter by 1-inch shackle padlock.
   e. Circuit breaker compartments shall only permit the interchange of circuit breaker removable elements of the same type and rating.

4. Auxiliary Transformer Compartment: Auxiliary Transformer compartment shall be designed to house a stationary rackable power fuses disconnecting device, bus duct, or feeder cable terminations. Hinged and bolted grounded metal screens shall provide a secondary barrier against inadvertent access to components and primary connections, which may remain energized at high voltage when the disconnecting device is in the open position. A key interlock shall prevent the opening of the compartment door unless the Low Voltage (LV) main circuit breaker if the load breaker panel is in the OPEN position as indicated in the RFP Plans. The fused disconnecting device shall comply with ANSI C37.30, C37.31, C37.32, C37.33, C37.34, and C37.46 standards.

5. Potential Transformer Compartment: Potential transformer compartment shall be designed to house the specified transformer assembly. Compartment door shall be furnished with interlock to prevent access to the transformer and primary fuses unless they are disconnected from the primary circuit. The CONNECTED/DISCONNECTED positions shall be clearly visible when the compartment front door is closed. Means shall be provided to prevent accidental access to the stationary primary contacts when the transformer and fuses are not in the CONNECTED position.

6. Main Bus:
   a. The main three-phase bus shall be comprised of electrical grade copper. Bus shall be fully insulated over its entire length with flame-retardant, non-
hygroscopic, track-resistant insulation. All bus tap connections, including bus taps and circuit breaker connections, shall be silver-plated. Standoff bus insulators shall be molded epoxy or porcelain construction.

b. The main bus and connections shall be braced to withstand the mechanical stresses associated with rated short-circuit momentary currents without deformation or damage to supports. Bus shall comply with NEMA BU 1, NEMA CC 1 and IEEE C37.23 standards.

c. Bus compartments within the metal-clad enclosed sections shall be isolated to metal-clad standards and that all bus bars within the metal-enclosed sections shall be insulated in accordance with metal-clad standards.

7. Ground Bus: a copper ground bus, not less than 2 x 1/4 inch shall extend the length of the switchgear sections with all bolted joints silver-plated. In each switchgear unit, where power buses enter or leave the switchgear at the top, a copper ground bus, not less than 1 x 1/8 inch shall be extended from the main ground bus, up to the top of the unit. All joints in the ground bus shall be made with a minimum of two bolts.

8. Control Power Bus:
   a. A 125 V dc control power bus shall be provided along the entire switchgear assembly for circuit breaker and auxiliary transformer fused load disconnect switch operation. Control power for the switchgear will be obtained from the control power battery and accessories specified in Section 34 20 45 – DC Control Power System. Fuses shall comply with NEMA FU 1 standard.
   b. A double-pole pullout fuse block shall be provided at the medium voltage circuit breaker and the auxiliary transformer fused disconnect switch compartment. The device shall effectively isolate the operating mechanism from the control power bus.

9. Utility Company Service Entry:
   a. Each switchgear assembly shall have provision for utility company service feeder cables entering from below, complying with ANSI C2 standard.
   b. The 12.47 kV switchgear incoming service feeder cabling compartment shall have adequate space to accommodate utility potheads for the incoming Hawaiian Electric Company (HECO) utility cables. Provisions for supporting, connecting, and shield grounding the service feeder cables shall be coordinated with HECO requirements. Surge arresters shall be mounted in a separate compartment from that provided for the utility service feeder cables. The compartment shall allow easy access and servicing of the ac arrestors.

10. Bus Transition Units: Bus transition units shall be provided, with each switchgear assembly as required by Contractor’s design of lineup. The transition unit structures shall be full height with front and rear bolted panels. Front panel shall be in line with those of the adjacent switchgear sections.

11. Space Heaters: Each switchgear assembly shall be furnished with thermostatically controlled adequately sized space heaters to prevent moisture contamination of the internal components. See section 34 20 50 – Miscellaneous Materials and Devices, for further requirements.
2.02 MEDIUM-VOLTAGE AC CIRCUIT BREAKERS

A. Circuit breakers shall comply with the requirements given in ANSI C37.01, C37.04, C37.11, and NEMA SG 4.

B. Type and Ratings:
   1. Type: The circuit breakers shall be indoor, three-pole, draw-out type, with sealed vacuum interrupters, and motor-charged spring-operated mechanisms. Circuit breakers of each type and rating shall be physically and electrically interchangeable.

   2. Rating: The circuit breakers shall be rated on a symmetrical current basis and have the following ratings and required related capabilities as defined in ANSI C37.04:
      a. Nominal Operating Voltage, kV, rms: 12.47 kV or 11.5 kV rms, as indicated on RFP Plans
      b. Rated Maximum Voltage, kV, rms: 15
      c. Rated Continuous Current at 60 Hz, amperes, rms: 1,200
      d. Required Symmetrical Current Interrupting Capability at Nominal Operating Voltage, kilo amperes, rms, minimum: 24
      e. Required Closing and Latching Capability, kilo ampere, rms, maximum: 39
      f. Rated Permissible Tripping Delay, Seconds: 2
      g. Rated Interrupting Time, Cycles, maximum: 5

C. Insulation Structure: Materials used for circuit breaker insulation shall be of a noncombustible, nonhygroscopic, and tracking resistant type. The mechanical strength and physical characteristics of the insulation structure shall match the stresses imposed by the circuit breaker required closing and latching current capability.

D. Removable Assembly:
   1. The circuit breaker removable elements shall be truck-mounted or cradle-mounted with pull-bar or handles suitable for manual removal and insertion of the element out of and into the stationary compartment.

   2. The removable element shall be provided with a fully interlocked, manually operated racking mechanism to move the circuit breaker between TEST/DISCONNECTED, and CONNECTED positions. A clearly visible position indicator shall be provided.

   3. The removable element frame shall be provided with a full front metal shield to prevent access to any live primary bus or load terminals when the circuit breaker is in the CONNECTED position.

   4. The circuit breaker removable element’s primary disconnecting contacts shall be provided with heavy-duty, self-aligning, spring-loaded, silver-plated, copper disconnect fingers that engage with the line-and load-side stationary disconnecting contacts.

   5. The circuit breaker interrupters shall be provided with means for determining contact wear without dismantling. The circuit breakers shall be furnished with splitter plate or magnetic coil type arc interruption chutes, which shall provide rapid interruption of all currents totally within the chute assembly.
6. Control wiring connections, from circuit breaker compartment to the removable element, shall have provisions for maintaining or automatically reinstating circuit continuity when the removable element is moved between CONNECTED and TEST positions. Suitable means shall be provided for simultaneous disconnection of control wiring connections when the removable element is fully withdrawn from the compartment.

7. Circuit breakers shall be provided with auxiliary switches for functions specified and as indicated, and two spare switches wired to control compartment.

E. Operating Mechanism:

1. The circuit breaker operating mechanism shall be of the motor-charged spring-operated type. The design of the mechanism shall prevent overcharging and ensure that the release of stored energy for closing the circuit breaker main contacts is prevented unless the mechanism has been fully charged. The design shall be mechanically trip-free. Energy storage shall be sufficient for an opening-closing-opening operation at the maximum symmetrical current interrupting capability of the circuit breaker.

2. The spring-operated mechanism shall be automatically recharged within 15 seconds after each circuit breaker closing operation. Mechanism shall have provisions for manually charging the closing springs.

3. The stored-energy mechanism shall be provided with a mechanical indicator to show the CHARGED and DISCHARGED status of the closing springs. Provide an interlock to prevent the complete withdrawal of the circuit breaker removable element from the stationary compartment when the mechanism is in a fully charged state; or alternatively, automatically discharge the stored energy when the removable element is withdrawn from or inserted into the compartment.

4. Each mechanism shall be provided with a non-resettable mechanical register type operation counter to record each circuit breaker close/open operating cycle.

5. The mechanism shall be provided with OPEN and CLOSE mechanical control pushbutton, mounted on the removable element escutcheon plate, for test purposes and for use in emergency. The mechanism shall also be furnished with an easily readable mechanical position indicator, mounted on the removable element, to indicate the OPEN and CLOSED positions of the main moving contacts.

F. Circuit Breaker Control:

1. The circuit breaker shall be designed for both local and remote supervisory electrical control operation at 125 V dc nominal control power supply.

2. The closing mechanism shall be provided with a spring release coil, antipump relay, and spring charging motor suitable for operation over a voltage range of 100 to 140 V. The tripping mechanism shall be provided with a shunt trip coil suitable for operation over a voltage range of 70 to 140 V.
2.03 AUXILIARY TRANSFORMER COMPARTMENT

A. Auxiliary Compartment: The compartment shall contain the draw out rackable truck type power fuse disconnecting device, power fuses, the auxiliary power transformer, and key interlock function in accordance with the single line diagram. An impact resistant glass-viewing window shall be installed on the front of the compartment to view the status of the fuse indicators.

B. Fuses:
   1. The transformer shall be protected with current-limiting primary fuses and shall be designed to withstand the basic impulse level of the switch. Fuses shall comply with ANSI 37.41 standards.
   2. Fuses shall be mounted in a draw-out compartment truck assembly and shall be moved between the connected and disconnected position via closed door racking and so arranged that the unit can not be withdrawn from the operating position via the racking device with the door closed. In the withdrawn position, the fuses shall be completely disconnected from service and all exposed parts shall be visibly grounded.
   3. The fused disconnecting switch device for isolating the auxiliary service transformer shall disconnect power to the station auxiliary transformer with the primary fuses automatically disconnected.
   4. The draw out compartment shall incorporate extension rails to allow changing fuses and general maintenance without the need to take the truck assembly completely out of its compartment.
   5. The draw out assembly shall utilize the same or similar racking device as the High Voltage ac breaker to provide for interchangeability of parts.
   6. The current limiting primary fuses shall have a 12.47 kV or 11.5 kV nominal rating as indicated on the RFP Plans. See Section 34 20 50 – Miscellaneous Materials and Devices, for further requirements.

C. Auxiliary Transformers:
   1. The transformer shall be of a dry type rated at 12.47 kV or 11.5 kV nominal primary voltages, three-phase, 4-wire as indicated on the RFP Plans and designed to withstand the Basic Impulse Level (BIL) of the switchgear.
   2. The transformer shall have a secondary voltage rating of 120/208– volt classification.

D. Key Interlocking: The primary fused disconnecting device shall be key interlocked with the LV circuit breaker power panel main circuit breaker to prevent deenergization of transformer under load. Withdrawal of the truck assembly without first opening the main LV circuit breaker shall not be allowed. The key shall remain captive in the LV panel until the main LV circuit breaker is opened. If the key is removed from the LV circuit breaker, it shall not be possible to close the main LV circuit breaker. The key interlocking shall also prevent the connection of the portable generator from providing a reverse feed to the medium voltage bus.

2.04 SURGE ARRESTERS

A. Type: Surge arresters shall comply with the requirements of ANSI C62.1 and C62.2, as applicable, and shall be intermediate class gapless metal oxide type, suitable for
mounting inside a separate metal enclosure. Arresters shall be provided with a pressure relief diaphragm.

B. Ratings: Arrester ratings, kV, rms shall be suitable for use at the utility company nominal service voltage of 12 kV, three-phase, 60 Hz as indicated. Required arrester ratings are as follows:

<table>
<thead>
<tr>
<th>Nominal System Sparkover Voltage kV, rms</th>
<th>Arrester Voltage Rating kV, rms</th>
<th>Maximum 0.5 microsecond Discharge Arrester MCOV 1</th>
<th>Voltage kV, Crest 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.47 and 11.5Δ</td>
<td>15</td>
<td>12.6</td>
<td>43.3</td>
</tr>
</tbody>
</table>

1 Maximum Continuous Operating Voltage
2 Equivalent of a fast front 5 kA current producing a voltage wave cresting in 0.5 microsecond 

C. Arrangement:

1. Arrester pressure relief diaphragm shall be arranged in the enclosure so vent ports are directed away from all adjacent apparatus. Preferably, the generated ionized gases during normal operation are vented to outside of the switchgear enclosure.

2. Arrester ground terminals shall be directly connected to the switchgear main ground bus.

3. Arresters shall be mounted properly to maintain the required clearances for the voltage class from adjacent metallic enclosures.

2.05 RELAYS

A. Switchgear assemblies shall be furnished with relaying systems and related functions as indicated in the RFP Plans and as further specified herein.

B. Additional components, such as auxiliary relays, isolating diodes, and other devices not indicated but required for a complete fully functional system, shall be furnished and installed.

C. Each relay shall have a sealed dust cover, which shall keep the inside of the case free of dust and moisture.

D. Protective devices provided shall prevent damage to the individual parts of the equipment due to short-circuit, transient voltage conditions and overloads.

E. Control and auxiliary relays shall be electro-mechanical type. Solid-state type auxiliary relays are acceptable provided their output contacts, if required to interface with other systems such as the Programmable Logic Controller (PLC) are independent and potential free.

F. Unless stated otherwise, relays requiring control power shall be able to operate properly with station battery voltage varying at least between 125 plus 10 / minus 15 percent V dc.

G. All relay contacts shall be correctly rated for the intended duty, and shall meet the required performance with no less than 50 percent spare margins at the worst-case scenario.
H. AC Multifunction Protection Relay (MFPR):

1. The protective relay located in the ac switchgear shall be a solid-state integrated relay package with programmable multifunctions with self-checking features.

2. The relay shall have opto-isolated inputs with (Trip/Close) monitoring for the detection of a failed circuit regardless of the breaker state.

3. The relay shall operate with both wye-connected or open-delta-connected potential transformers and current transformers as indicated on the RFP Plans.

4. The relay shall comply with IEEE C37.91 surge withstand capability standards, and ANSI C39.5 safety requirements.

5. The relays shall be built to operate in a hostile harsh environment utilizing conformally coated circuit boards to protect them from moisture, temperature variations, salt spray, organic attack (fungus), and aggressive chemicals and vapors.

6. The relay shall be provided for flush or semi-flush mounting on doors. They shall be of drawout construction to facilitate testing, maintenance and interchange flexibility.

7. The relay shall be provided with application software, windows based, and provided on CD or DVD type media. All programs licenses shall become the property of the City. Any cables required for programming shall be provided.

8. To protect against damage to equipment, property, and personnel, to assure continuity of operation and prevent false tripping or malfunction, a power system study shall determine the settings to be programmed and tested. See Section 26 05 73 – Overcurrent Protective Device Coordination Study, and Section 34 20 01 – Traction Electrification - General Requirements, for further requirements.

9. Protection function shall allow setting adjustments for a trip, an alarm, or a control signal with separate output contacts for each operating function including visual indication of the relay functions operation. The output contacts shall be rated for tripping duty in accordance with IEEE C37.90 standards.

10. AC relays functions shall include functions 227,247,250/251,250N/251N for protection and monitoring required as indicated in the RFP Plans. Device numbers are as described as indicated in the RFP Plans.

11. Relays shall include standard metering and monitoring functions for display of ac current and voltage for display on the liquid crystal display (LCD) screen specified in Section 34 20 35 – Control and Annunciation System, and as indicated in the RFP Plans.

12. The relay shall incorporate an event recorder with a record of the last events, time tagged.

13. The relay shall have a storage capacity of data logger with storage capability of recording actual values at user-defined intervals.

14. The relay shall incorporate an operation counter non-resettable to record each circuit breaker close/open operating cycle.

15. User interfaces shall include:
   a. A large character display, navigation keys, and a full numeric keypad.
b. Indicator LEDs on the front panel which shall provide a quick visual indication of status.

c. As described in Section 34 20 35 – Control and Annunciation System, the relay shall be as part of a Local Area Network system in conjunction with the Master PLC located in the PLC/Annunciator panel forming a completed control and annunciation network for the requirements of the ac system operation.

d. The relay shall have RS485 ports with communications protocol serial ports including those to connect a laptop computer to utilize Windows-based, setup graphical terminal interface program to perform testing and download system records.

e. A simulation feature shall be included to allow testing without the need for external voltage and current inputs.

2.06 LOCKOUT RELAYS

A. Lockout relays shall be high-speed, multi-contact, hand reset type with oval handles and mechanical targets that indicate whether the relays are in the tripped or reset position.

B. Lockout relays shall be General Electric Type HEA, Westinghouse Type WL, or equal.

C. Lockout relay device function No. 286 shall interface with the PLC as described in Section 34 20 35 – Controls and Annunciation System. The PLC shall be provided with logic to trip the incoming service ac circuit breaker.

D. If the Contractor chooses to implement the Lockout feature under software logic through the TPSS, the PLC system as specified in Section 34 20 35 – Control and Annunciation System, a manual reset shall be required at the PLC/Annunciator cabinet.

E. Provide 286 device lockout trip contacts for connection to the PLC for alarm at the LCD screen.

2.07 INSTRUMENT TRANSFORMERS

A. Instrument transformers shall be installed so that they are accessible for maintenance and replacement.

B. Instrument transformers shall comply with ANSI C57.13, NEMA EI 21.1, and as described herein.

C. Current Transformers:

1. Current transformers shall be multi-ratio, epoxy-encapsulated, wound type. The transformers shall be capable of withstanding the thermal and mechanical stresses imposed by currents equal to the specified switchgear momentary ratings. Current transformers shall have a mounting frame bolted securely to the switchgear frame.

2. Current transformers shall comply with the requirements for ANSI C57.13 C class relaying and 0.3 class metering accuracy under the burdens imposed by the devices connected and ratios indicated.

3. Current transformers shall be installed in a compartment isolated from the circuit control panel and high-voltage equipment except for primary connection bushings. Current transformer and secondary wiring shall be protected from
induced voltages by metallic shielding to minimize the possibility of insulation failure.

4. Current transformer secondary wiring terminal blocks shall have covers. Secondary wiring shall be run to readily identifiable terminal blocks in the control compartment. Terminal blocks shall be furnished with integral shorting bars.

5. Current transformers shall be adequately sized to provide linear output through the full range of the calculated maximum short circuit value and shall not saturate causing error of the measured current during the short circuit event.

D. Bus Potential Transformers:

1. Potential transformers shall be molded rubber or epoxy-encapsulated, with current limiting primary fuses.

2. Potential transformers shall be of a draw-out construction, wound type with polarity markers, suitable for operating meters and relays.

3. Potential transformers shall have an accuracy classification of 0.3Z, 200 kV BIL, at the standard burden imposed by the connected devices in accordance with ANSI C57.13.

4. Potential transformers shall be Group 2 class for line-to-line or line-to-neutral connection as appropriate for the insulation class required. Primary voltage ratings and transformation ratios of 12,470 volts primary to 115 volts secondary and 11,500 volts primary to 115 volts secondary as required.

5. Temperature Rise: Maximum allowable temperature rise shall not exceed 131 degrees Fahrenheit under continuous full load above an average ambient temperature of 77 degrees Fahrenheit. Temperature rise measured by winding resistance shall be 86 degrees Fahrenheit or by hottest spot in winding shall be 104 degrees Fahrenheit.

E. Utility Company Metering:

1. A totally enclosed cubicle shall be provided with in each 12.47 kV and 11.5 kV switchgear assembly of the TPSS for utility company service metering, as indicated in the RFP Plans.

2. The cubicle shall house instrument transformers and meters that will be furnished and installed by the utility company.

3. The cubicle shall be provided with a set of 3-phase, 1,200 A main bus and supports, complete with terminals and connections as required for coupling of utility company instrument transformers and meters. Main bus shall have an insulation level equal to that of the switchgear bus and shall be fully integrated with and connected to the adjacent switchgear bus. Switchgear ground bus shall be extended into the metering cubicle.

4. Provide HECO kWh energy usage and kilowatt power demand with peak demand reset function and indication of measurements.

5. Metering cubicles for the HECO service shall comply with the utility requirements.

6. For the GBS utility interface, see Section 34 20 50 – Miscellaneous Materials and Device, and the RFP Plans.
2.08 SUPERVISORY CONTROL AND ANNUNCIATION REQUIREMENTS

A. Supervisory control and annunciation circuits shall be provided for the ac switchgear and interface with the substation PLC/Annunciator panel. See Section 34 20 35 – Control and Annunciation System, and the RFP Plans for further requirements.

1. AC Switchgear Control Circuits:
   a. Circuit breaker – CLOSE
   b. Circuit breaker – TRIP

2. Local Status Indication Circuits on each ac switchgear:
   a. Circuit breaker – CLOSED
   b. Circuit breaker – OPEN
   c. Circuit breaker – TRIPPED
   d. TPSS master Local/Remote Selector Switch Indication:
      1) Local Indication (Amber)
      2) Remote Indication (Blue)

3. Remote Supervisory Control and Annunciation Circuits:
   a. Circuit breaker – CLOSED
   b. Circuit breaker – OPEN
   c. Circuit breaker – TRIPPED
   d. Lockout Relay 286 – TRIPPED

B. The MFPR relays shall be integrated with the Master PLC located in the PLC/Annunciator panel through a local area network. See Section 34 20 35 – Control and Annunciation System, for further requirements.

2.09 SWITCHGEAR MAINTENANCE ACCESSORIES

A. Each complete ac power switchgear assembly shall be provided with the following:

1. One circuit breaker test cabinet, wall-mounted, complete with test jumper cables and connectors.

2. One set of circuit breakers removal accessories including lifting and handling devices.

3. One manual ground and test device without remote control, consisting of the following:
   a. Six bushings mounted in proper configuration to engage contacts connected to the bus and line stationary contacts.
   b. Two totally enclosed and completely isolated compartments for terminating the other ends of the bushings. One compartment shall be identified as BUS CONNECTIONS and the other compartment as LINE CONNECTIONS. Provide each compartment with a hinged door equipped with padlocking facilities.
   c. Insulated barriers shall be provided between the bus and line compartments and between each phase bushing and on the side walls of each compartment. Bushing termination in the bus and line compartments shall be provided with ground tails.
d. A towel bar grounding ring, attached to the front of the device at a convenient location, shall be provided to accommodate six portable ground lead clamps. This ground ring shall be attached to a separable grounding contact on the device, which will connect to the main ground bus in the switchgear unit.

2.10 INITIAL PROVISIONING

A. Each complete ac power switchgear assembly shall be provided with an itemized list of parts with quantities, order preference, and price that the Contractor recommends for 2 years of operation before restocking. The reference number for each item shall include the Contractor’s and the original manufacturer’s part numbers. See Technical Provision TP-03, “O&M Performance Requirements” for further requirements.

PART 3 – EXECUTION

3.01 INSTALLATION

A. The switchgear design is for indoor use only.
B. Install the specified ac switchgear equipment within the substation prefabricated enclosure secure, plumb, level, and in true alignment with related adjoining work.
C. Install supporting members, fastenings, framing hangers, bracing, brackets, straps, bolts, and angles, as required, to set and rigidly connect the work.
D. Control erection tolerance requirements so as not to impair the strength, safety, serviceability, or appearance.
E. Exercise special care during installation to avoid overloading any part of the structure. Repair or replace any item damaged due to overloading, at no additional cost to the City.
F. Once installed, there should be absolutely no access to the top of the switchgear, nor should any cables be run over the top of the switchgear.
G. All primary and secondary cables shall be fed from bottom entrances only, unless a special rear extension is provided.
H. Shipping splits must be bolted together in the field. Provide barriers and bolted pieces with a seal of silicone to assist in the prevention of gases between compartments. The integrity of these seals must be maintained.

3.02 TESTING

A. See Section 34 20 80 – Traction Electrification System Testing, for testing requirements.
B. See Technical Provision TP-02, “Verification Testing and Acceptance” for further requirements.
SECTION 34 20 15
RECTIFIER TRANSFORMER

PART 1 – GENERAL

1.01 SUMMARY
A. Description: The Work in this Section includes the requirements for the design, procurement, and installation of the rectifier transformer equipment and materials, which receives its power from the substation medium-voltage ac power switchgear and supplies power to the associated ac-dc conversion traction rectifier assembly. The Work includes for providing each transformer assembly comprised of hardware, interconnecting buses, wiring, and related devices.

B. Section Includes:
1. General
2. Rectifier Transformers
3. Initial Provisioning
4. Supervisory Control and Annunciation Requirements

C. Related Sections:
1. Section 34 20 01 – Traction Electrification – General Requirements
2. Section 34 20 05 – Prefabricated Enclosures
3. Section 34 20 35 – Control and Annunciation System
4. Section 34 20 50 – Miscellaneous Materials and Devices
5. Section 34 20 80 – Traction Electrification System Testing

1.02 PRICE AND PAYMENT PROCEDURES
A. General: Separate measurement or payment will not be made for the Work required under this Section. All cost in connection with Work specified herein will be considered to be included with the related item of work in the General Conditions, or incidental to the Work.

1.03 REFERENCES
A. American National Standards Institute (ANSI):
1. ANSI C34.2 Practices and Requirements for Semiconductor Power Rectifier
2. ANSI C57.12.01 General Requirements for Dry Type Distribution Transformers
3. ASI C57.12.91 IEEE Standard Test Code for Dry-Type Distribution and Power Transformers
B. National Electrical Manufacturers Association (NEMA):
   1. NEMA SG 5  Power Switchgear Assemblies / Audible Sound Levels for Dry Type Transformers
   2. NEMA TR1  Transformers, Regulators and Reactors

1.04 PERFORMANCE REQUIREMENTS

A. Coordinate the installation of the rectifier transformer with the requirements of Section 34 20 05 – Prefabricated Enclosures, and as indicated on the RFP Plans.

B. See Section 34 20 01 – Traction Electrification - General Requirements, for abbreviations, definitions, device requirements and further requirements of the TES equipment.

1.05 SUBMITTALS

A. General: Refer to General Conditions for Submittal Procedures, and for Shop Drawings, Product Data, and Samples requirements and procedures.

B. Submit all data, design plans, procedures and samples in accordance with Section 34 20 01 – Traction Electrification - General Requirements, including, but not limited to the following:
   1. Manufacturer’s product description, catalog data, and information.
   2. Manufacturer’s arrangement and detail drawings for each item of transformer assembly.
   3. Internal wiring and elementary diagrams.
   4. Transformer circuit diagrams.
   5. Operation and maintenance manual, including spare parts list.
   8. Design calculations of the following:
      a. Rectifier transformer resistance
      b. Rectifier transformer impedance
      c. Rectifier transformer X/R ratio
      d. Transformer-rectifier unit voltage regulation curve
      e. Transformer-rectifier efficiency-load curve
      f. Rectifier transformer temperature rise curve
      g. Rectifier transformer power loss curve
      h. Rectifier power factor-load curve
1.06 QUALITY ASSURANCE

A. General: Refer to General Conditions for quality assurance requirements and procedures.

B. Comply with all applicable Federal, State, and Local Laws, Regulations, and Codes including those referenced in Article 1.03.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As the Rectifier Transformer is installed within the Prefabricated Enclosure, the Core Systems DBOM Contractor shall coordinate the delivery, storage, and handling of the Rectifier Transformer with the requirements as described in Section 34 20 05 – Prefabricated Enclosures.

1.08 WARRANTY

A. The Core Systems Design-Build-Operate-Maintain (DBOM) Contractor suppliers shall warrant that their products are free from defects. Warranty shall conform to the requirements of the General Conditions.

PART 2 – PRODUCTS

2.01 GENERAL

A. Types and Ratings: The traction power transformer shall be 12-phase, delta-to-delta wye, and designed for operation with rectifier circuit No. 31 as identified in ANSI C34.2. The transformer shall be designed to meet the extra-heavy traction rating class loading requirements without damage, as follows: after constant full load temperatures are reached, the transformer and rectifier unit shall be capable of operating at 150 percent of rated load amperes for 2 hours and a superimposed cycle of overloads consisting of five periods of 1 minute each at 300 percent of rated load amperes followed by one period of 450 percent load amperes for 15 seconds at the end of the 2 hour-hour load cycle period.

B. Fault Current Withstand: The transformer, including interconnecting bus and switchgear, shall be certified as capable of withstanding 300 percent of the theoretical maximum short-circuit current, with the short circuit applied at the load terminal of the transformer, without damage to the transformer for the time period for the ac rectifier transformer feeder breaker to open and clear the fault.

C. Efficiency: The overall efficiency of each transformer shall be greater than 98 percent at the kilowatt rating.

D. Total Combined Transformer and Rectifier Unit Voltage Regulation: The transformer shall have linear inherent regulation of 4.5 percent (plus or minus 0.5 percent), between one percent and 300 percent of rated load, when rated primary voltage is applied to the ac line terminals of the rectifier transformer.

2.02 RECTIFIER TRANSFORMER

A. Rectifier transformers shall comply with the applicable requirements of ANSI C34.2, C57.12.01, C57.12.91; NEMA SG5 and TR1; and with these Specifications.
B. Types and Ratings:

1. Rectifier transformer shall be indoor, three-phase, 60 Hz, ventilated, dry-type, self-cooled, class AA designed for 12-pulse rectification application. Transformers shall be designed, and provisions made, for the future addition of forced-air-cooling equipment.

2. Transformers with ac winding and rated voltage of 12,470 V or 11,500 V shall be conventional dry-type, with ac winding BIL ratings shall not be less than 60 kV.

3. Secondary windings rated voltage, ampacity, related characteristics, and winding connection shall be designed and meet the performance criteria for use with the required power rectifier circuit configuration. Winding BIL shall not be less than 20 kV.

C. Impedance: Transformer impedances shall be selected to provide the required minimum voltages at the rectifier load terminals under the specified loading conditions and utility service system characteristics indicated. Impedances shall also be coordinated with the dc power switchgear circuit breaker short-circuit ratings associated with bolted faults at the feeder breaker load side terminals.

D. Transformer Temperature Limits: Winding temperature limit requirements are based on the transformers being housed in a fully equipped self-ventilated substation enclosure, with external ambient temperatures of 86 degrees Fahrenheit average, 104 degrees Fahrenheit maximum.

E. For extra-heavy traction service rating dry type transformers, the average winding temperature rise measured by resistance, when operating at 100 percent rated continuous load shall not exceed 248 degrees Fahrenheit and at 150 percent of rated load for 2 hours shall not exceed 302 degrees Fahrenheit. Whichever is the more stringent for dry type (Class H1 insulation systems) shall be provided.

F. Nose Level: Rectifier transformer and its associated interphase transformer noise level shall not exceed 65 dBA when measured in accordance with the conditions outlined in Section 34 20 01 – Traction Electrification - General Requirements.

G. Construction:

1. Mechanical Characteristics:
   a. General: Transformers shall be so designed that parts are easily accessible for maintenance. Enclosure shall be moisture-resistant and shall be substantial enough to protect the transformer coils against accidental mechanical damage.
   b. Enclosure: The transformer enclosure shall be self-supporting steel construction of not less than 12-gauge formed steel sheets constructed of sufficient strength. Provide with bolted removable panels for access to the winding taps, core, and coils. Panels shall be provided with close mesh ventilating grilles, not less than 6 inches above the floor, or where they could allow entry of debris and dirt. Complete case structure shall be removable.
      1) Enclosure sections shall be electrically bonded together such that the entire enclosure is a grounded, equipotential surface. Welding, bolting of bare metal-to-metal surfaces, or electrical bonding jumpers are acceptable bonding methods.
2) Doors shall be provided in the front and rear of the transformer for access to the transformer, incoming primary connections, tap terminals, and control circuit terminals. Access panels shall be formed of not less than 14-gauge sheet steel and shall be properly reinforced against distortions by suitable flanges and stiffening members. Each access panel shall be provided with a heavy-duty exterior handle on opposite panel sides, located to approximately balance the weight of the panel during panel removal. Handles shall be commercially available hardware items; shop-fabricated wire handles are not acceptable.

3) A removable, transparent insulating barrier shall be mounted inside the enclosure across the front access panels to block access to potentially live parts unless the barrier is removed. The barrier shall be firmly bolted to the enclosure frame.

c. Base Structure: The base structure shall be comprised of base members suitable for mounting the core and coil assembly and for skidding or rolling the complete assembly in any direction. The base assembly shall have provisions for jacking the base-mounted core and core assembly, to permit insertion of rollers between floor and base. The base structure shall be attached to the substation floor channels through tuned vibration dampers, to mitigate transfer of noise by mutual resonance.

d. Core and Windings: Core and coils shall be rigidly braced to withstand the mechanical forces under short-circuit conditions and resist normal vibration and shock forces during shipment. Core lamination shall be no-aging, cold rolled, high magnetic permeability silicon steel. Core legs shall be firmly clamped by glass fiber bands, structural steel members and insulated bolts. The outside surfaces of the core shall be protected by an evenly applied coating of resin base paint. Core clamps and structural members shall be grounded by a bolted copper strap. The high-voltage ac and low-voltage output winding coil assembly shall permit ready circulation of air in the core-to-coil and coil-to-core insulation system. Eye bolts shall be furnished for lifting the entire assembly by hoist or crane.

2. Winding Insulation System:
   a. Coil insulation system shall be appropriate for the traction rating class and limiting temperatures specified. Insulation systems shall be nonhydroscopic, have high thermal stability and mechanical strength suitable for the daily loading cycles imposed by traction service duty, and mechanical force due to vibration and short-circuit currents.
   b. Dry-type insulation system shall be Class H, 428 degrees Fahrenheit construction.

3. Winding Taps:
   a. Each rectifier transformer shall be provided with six taps on the ac windings, to provide means of adjusting for sustained departures of the service voltage. Each tap shall adjust the output voltage by nominal 2.5 percent increments. Three rated kVA taps shall increase the output voltage and three rated kVA taps shall reduce the output voltage.
   b. Taps shall be rigidly supported by brazing to the coils. Tap connections shall be clearly identified and tap positions changed by the movement of bolted links between connection points.
4. Buses and Bus Connections: Buses shall be electrical grade copper and braced to withstand the maximum theoretical short circuit forces. Bus connections shall be silver plated.

H. Accessories: Transformers shall be furnished with the accessories as follows:

1. Dial-type, winding hot-spot temperature indicator, device No. 249WT with maximum reading pointer and with thermocouple incorporated in an output winding coil at the point of highest expected temperature rise. The device shall be factory-set with first-stage operation to initiate remote supervisory and local annunciation. The second stage shall interface with the Programmable Logic Controller (PLC) provided under Section 34 20 35 – Controls and Annunciation. Logic shall be provided in the PLC to trip the lockout trip relay, device No. 186. The circuits shall be wired to terminal blocks in a control box mounted on the enclosure.

2. Continuous copper ground bus with grounding pads on diametrically opposite corners, for connection to the substation ground grid.

3. Protective screen: The top of open transformer coils shall be furnished with non-ferrous screen mesh to preclude foreign materials from falling between the transformer coils.

4. Space Heaters: Each Transformer assembly shall be furnished with thermostatically controlled adequately sized space heaters to prevent moisture contamination of the internal components. See Section 34 20 50 – Miscellaneous Materials and Devices, for further requirements.

2.03 INITIAL PROVISIONING

A. Each complete rectifier transformer assembly shall be provided with an itemized list of parts with quantities, order preference, and price that the Contractor recommends for 2 years of operation before restocking. The reference number for each item shall include the Contractor’s and the original manufacturer’s part numbers. See Technical Provision TP-03, “O&M Performance Requirements” for further requirements.

2.04 SUPERVISORY CONTROL AND ANNUNCIATION REQUIREMENTS

A. Remote supervisory control and annunciation circuits shall be provided for the transformer to interface with the substation PLC/Annunciator panel. Interlocks with contacts are to be provided for the safety shutdown if either door is opened while the transformer is energized. See Section 34 20 35 – Control and Annunciation System, and the RFP Plans for further requirements.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install the transformer and the bus assemblies within each substation enclosure secure, plumb, level, and in true alignment with related adjoining work. The rear compartment openings shall be in alignment with enclosure’s exterior access doors. See Section 34 20 01 – Traction Electrification - General Requirements, for further requirements for the rectifier transformer.
3.02 TESTING

A. See Section 34 20 80 – Traction Electrification System Testing, for further requirements for the rectifier transformer.

B. See Technical Provision TP-02, “Verification Testing and Acceptance” for further requirements.

END OF SECTION
SECTION 34 20 20
TRACTION RECTIFIER

PART 1 – GENERAL

1.01 SUMMARY

A. Description: The Work in this Section includes the requirements for the design, procurement, and installation of the traction rectifier ac-dc conversion equipment and materials, that receives power from the substation rectifier transformer and supplies power to the associated dc power switchgear. Each rectifier assembly is comprised of a semiconductor power rectifier complete with all standard and specified accessories, auxiliaries, controls, hardware, interconnecting buses, wiring, and related devices.

B. Section Includes:
   1. General
   2. Semiconductor Power Rectifiers
   3. Initial Provisioning
   4. Supervisory Control and Annunciation Requirements

C. Related Sections:
   1. Section 34 20 01 – Traction Electrification - General Requirements
   2. Section 34 20 05 – Prefabricated Enclosures
   3. Section 34 20 15 – Rectifier Transformer
   4. Section 34 20 30 – Negative Grounding Device
   5. Section 34 20 35 – Control and Annunciation.
   6. Section 34 20 45 – DC Control Power System
   7. Section 34 20 50 – Miscellaneous Materials and Devices
   8. Section 34 20 80 – Traction Electrification System Testing

1.02 PRICE AND PAYMENT PROCEDURES

A. General: Separate measurement or payment will not be made for the Work required under this Section. All cost in connection with Work specified herein will be considered to be included with the related item of work in the General Conditions requirements, or incidental to the Work.

1.03 CODES, STANDARDS, AND RECOMMENDED PRACTICES

A. American National Standards Institute (ANSI):
   1. ANSI C34.2 Semiconductor Power Rectifiers
   2. ANSI C37.31 Indoor Apparatus Insulators (For High Voltage Switches)

B. Electronic Industries Association (EIA):
   1. EIA RS-282 Silicon Rectifier Diodes and Stacks
C. Institute of Electrical and Electronics Engineers (IEEE):
   1. IEEE 316 Standard Requirements for Direct Current Shunts
   2. IEEE C62 IEEE Surge Protection Standards Collection

D. National Electrical Manufacturers Association (NEMA):
   1. NEMA R1-9 Rectifiers for Transportation Power Supplies
   2. NEMA 250 Enclosures for Electrical Equipment (1,000 Volts Maximum)

1.04 PERFORMANCE REQUIREMENTS

A. Coordinate the installation of the rectifier with the requirements of Section 34 20 05 – Prefabricated Enclosures, and as indicated on the RFP Plans.

B. See Section 34 20 01 – Traction Electrification - General Requirements, for abbreviations, definitions, device requirements and further requirements of the TES equipment.

1.05 SUBMITTALS

A. General: Refer to General Conditions requirements for Submittal Procedures, and for Shop Drawings, Product Data, and Samples requirements and procedures.

B. Submit all data, design plans, procedures and samples in accordance with Section 34 20 01 – Traction Electrification - General Requirement, including, but not limited to the following:
   1. Manufacturer’s product description, catalog data and information
   2. Manufacturer’s arrangement and detail drawings for each item of the ac-to-dc conversion assembly
   3. Internal wiring and elementary diagrams
   4. Power rectifier circuit diagrams
   5. Operation and maintenance manual, including spare parts list
   8. Design calculations of the following:
      a. Rectifier power factor-load curve
      b. Rectifier momentary peak and sustained short circuit currents
      c. Compliance with this Section on number of parallel diodes furnished

1.06 QUALITY ASSURANCE

A. General: Refer to General Conditions requirements for quality assurance requirements and procedures.
B. Comply with all applicable Federal, State, and Local Laws, Regulations, and Codes including those referenced in Article 1.03.

1.07 DELIVERY, STORAGE, AND HANDLING
A. As the Traction Rectifier is installed within the Prefabricated Enclosure, the Core Systems Design-Build-Operate-Maintain (DBOM) Contractor shall coordinate the delivery, storage and handling of the Traction rectifier with the requirements as described in Section 34 20 05 – Prefabricated Enclosures.

1.08 WARRANTY
A. The Core Systems DBOM Contractor suppliers shall warrant that their products are free from defects. Warranty shall conform to the requirements of the General Conditions requirements.

PART 2 – PRODUCTS

2.01 GENERAL
A. Types and Ratings: The traction power supply ac-to-dc conversion assemblies shall be 12-phase, double-way type, and designed for rectifier circuit No. 31 as identified in ANSI C34.2. The conversion assembly shall have a sufficient quantity of parallel diodes to fulfill the performance requirements of Article 2.01B herein, with one diode per diode group removed (“N+1” design). There are 12 diode groups in a circuit 31 rectifier. The assemblies shall have continuous output ratings as indicated, at 775 V dc. The assemblies shall be designed to meet the extra-heavy traction rating class loading requirements as specified in Section 34 20 15 – Rectifier Transformer.

B. Fault Current Withstand: The ac-to-dc conversion assemblies, including interconnecting bus and switchgear, shall be certified as capable of withstanding 100 percent of the theoretical maximum short-circuit current, with the short circuit applied at the load terminal of a dc feeder circuit breaker, without damage to any component for the time period for the ac rectifier transformer feeder breaker to open and clear the fault.

C. Total Voltage Regulation: See Section 34 20 15 – Rectifier Transformer for requirements of voltage regulation.

2.02 SEMICONDUCTOR POWER RECTIFIERS
A. Rectifiers shall comply with the requirements of ANSI C34.2, C62, EIA RS-282, NEMA R1-9 and as specified.

B. Type and Rating:
1. Rectifiers shall be indoor, natural convection direct air cooled, semiconductor type, mounted in a ventilated, freestanding, metal enclosure, and designed for a high or low resistance grounding system.

2. Rectifiers shall have a rated output voltage of nominal 775 V dc at rated continuous output current and shall be designed for the specified traction rating classes at a maximum ambient temperature of 104 degrees Fahrenheit.
C. Construction:
   1. Each rectifier unit shall be an integrated assembly consisting of silicon diodes, internal buses, and interphase transformer, negative disconnect switch, protective devices, control wiring, terminal blocks, and other required accessories.
   2. Heat transfer surfaces shall be designed for easy cleaning and to minimize accumulation of dust and other contaminants expected in the operating environment.
   3. Parallel stacks of diodes shall be electrically and geometrically similar and as symmetrical as practical to help balance the normal and surge electrical characteristics of each stack. The rectifier shall be designed to maintain current balance between parallel-connected diodes in each phase. This current balancing scheme shall hold individual diode currents within their capabilities under the load conditions including short circuits with one diode fuse open per circuit element. Current balancing shall not be achieved by use of selectively matched diodes.
   4. The rectifier shall be capable of carrying specified overloads and short-circuit current without exceeding safe junction temperature of the diodes with one diode fuse open per circuit element. Each diode shall be capable of withstanding, at its maximum operating temperature during blocking periods, repetitive voltages having a value of not less than 2.5 times its working peak reverse voltage without a permanent change in diode characteristics.
   5. The rms value of the dc ripple shall not exceed two and one half percent of the dc rms output of the rectifier.
   6. Current-limiting fuses shall be provided in the connection to each diode, complete with a fuse monitoring system. The monitoring system shall consist of a two-stage diode failure device 180-1 and 180-2 utilizing microswitches.
   7. Interphase transformer shall be designed for maximum suppression of noise, and shall be mounted on tuned vibration dampers to substantially mitigate the transfer of 360 Hz frequency vibration to the substation enclosure.

D. Rectifier Enclosure:
   1. Each rectifier NEMA 250, Type 1 rated enclosure shall be an indoor, ventilated, metal structure with hinged doors. The enclosure shall be assembled with a rigid self-supporting structural steel framework and shall have principal structural members bonded together. The enclosure shall be constructed of not less than No. 12 MSG sheet metal. The access doors or panels shall be not less than No. 14 MSG sheet metal.
   2. Convenient access shall be provided for normal maintenance and inspection. Each door shall be equipped with mechanical latches to hold the door fully and securely closed. Door stops shall be provided to hold the door in the open position. A shatterproof window or windows shall be provided to permit convenient inspection of the diodes and fuses. Doors shall be furnished with electrical interlocking contacts, device No. 133.
   3. A barrier shall be provided between positive and negative terminals of the rectifier.
E. Rectifier Buses and Bus Connections:
1. Rectifier buses shall be made of rigid, electrical grade copper with silver-plated contact surfaces, or aluminum with welded joints.
2. Buses shall be suitably braced between each other and to the enclosures with high-strength, non-sticking insulators.
3. Buses shall be designed to safely withstand the theoretical maximum short-circuit current without damage to the bus or the enclosure.
4. Bus shall be supported by stand-off insulators of porcelain or molded epoxy construction, with corrosion-resistant inserts, complying with ANSI C37.31. Insulation level shall be 4.2 kV ac, rms, for a rated maximum voltage of 1,000 V dc.

F. Negative Disconnect Switch:
1. A negative disconnect switch shall be included within separate metal-enclosed compartment at each rectifier unit. The disconnect switch shall be single-pole, single-throw, bolted contact, stationary type, rated at 1,000 V dc and with continuous and momentary current ratings to match the associated rectifier cathode dc circuit breaker ratings.
2. The disconnect switch shall be furnished with an insulated operating handle and key-interlocked with the rectifier-cathode circuit breaker. Interlocking shall prevent opening of the switch unless the cathode circuit breaker is open, and similarly, prevent the cathode circuit breaker from closing unless the disconnect switch is closed. See the RFP Plans for further requirements.
3. The dc negative feeder cables from the running rail and rectifier assembly shall be terminated to the load side of the negative disconnect switch through a dc shunt and associated copper bus bar. DC instrument shunts shall comply with the requirements of IEEE 316. Shunt output shall be 50 mV at 10,000 A.

G. Negative Bus Cubicle:
1. Construction: Negative bus cubicle shall be ventilated, freestanding, No. 12 manufacturer’s standard gage (MSG) metal enclosures, complying with NEMA 250, Type 1 requirements.
2. Bus and Bus Connections: Bus and bus connections shall be provided in accordance with Article 2.02E.1 through 4 herein.
3. Provide dc rated lightning and surge arresters from Negative Bus to ground as indicated in the RFP Plans. Surge arresters shall be of the spark gap gas tube type. The Core Systems DBOM Contractor shall provide adequately sized arrester complying with ANSI standards to meet the calculated lightning requirements as described in Section 34 20 01 – Traction Electrification - General Requirements. Arresters shall be as manufactured by Lightning Protection Corporation, or approved equal.
4. Provide adequate space for installation of Negative Grounding Device as specified in Section 34 20 30 – Negative Grounding Device.
H. Relays and Protective Devices: The following protective relays and devices shall be provided with each rectifier assembly:

1. A two-stage factory-set rectifier overtemperature detector, device No. 126 R1. First stage shall detect an abnormal rise in heat sink temperature and initiate local and remote supervisory annunciations. The second stage overtemperature detector device No. 126 R2 shall interface with the interface with the Programmable Logic Controller (PLC) provided under Section 34 20 35 – Controls and Annunciation. Logic shall be provided in the PLC to trip the lockout trip relay, device No.186 upon 126 R2 over temperature. See the RFP Plans for further requirements.

2. Diode failure device No. 180-1 and 180-2, shall initiate local and remote supervisory annunciations following the loss of any diode path. The first stage device No. 180-1 shall annunciate on any single diode failure. The second stage device No. 180-2 shall annunciate and interface with the PLC provided under Section 34 20 35 – Controls and Annunciation. Logic shall be provided in the PLC to trip the lockout trip relay, device No.186 upon 180-2 diode failure condition. See the RFP Plans for further requirements.

3. Surge protective device No. 103D-1 that will limit reverse current voltages across the silicon diodes to a value within the peak-reverse-voltage rating of the diode during voltage transients originating in either the alternating current or direct current power circuits. Device No. 103D-1 shall initiate local and remote supervisory annunciations should they become inoperative. Comply with IEEE C62 Surge Protection Standards.

4. Door interlocks contacts, device No. 133, located at the top and bottom of the rectifier enclosure doors. Contacts shall interface with the PLC provided under Section 34 20 35 – Controls and Annunciation. Logic shall be provided in the PLC to trip the lockout trip relay, device No.186 upon initiation of a device No. 133 initiation. See the RFP Plans for further requirements. The PLC logic shall prevent closing of the rectifier transformer, ac circuit breaker and rectifier cathode dc circuit breaker when any of the rectifier enclosure doors are open. Operation of any device No. 133 shall also initiate remote supervisory annunciation, as indicated in the RFP Plans.

5. Provide Lockout relay, device No. 186 device lockout trip with contacts for connection to the PLC for alarm at the Liquid Crystal Display (LCD) screen.

6. Rectifier protective relay and device contacts shall be wired to terminal blocks in the control compartment.

I. Enclosure Ground Relaying Resistance: Grounding shall be provided in accordance with High or Low resistance design in conformance with the design criteria of this Contract and as follows:

1. The rectifier enclosure shall be insulated from the substation enclosure floor and any adjacent grounded metal work. Enclosure ground bus shall be single point grounded by means of an insulated # 4/0 AWG copper conductor connected directly to the substation buried ground grid as indicated in the RFP Plans.

2. Provide a dual function adjustable instantaneous ground and active relay device No. 164G/A. Relays shall initiate local and remote supervisory annunciations and shall interface with the PLC provided under Section 34 20 35 – Controls and
Annunciation. Logic shall be provided in the PLC to trip the lockout trip relay, device No.186. See the RFP Plans for further requirements.

3. For positive to enclosure energized rectifier structure faults the entire TPSS facility shall be de-energized.

4. For enclosure, exposed to ground type faults provide alarm only.

5. Relays shall have inverse time delayed detection after the set value is reached. The relay shall have adjustable setting ranges for the 64 Ground function and 64 Alive function.

6. The grounding system relaying shall be designed to operate without damage when maximum system fault current flows to ground for the time required clearing the fault.

7. Relays shall have self monitoring, fail safe annunciation features. It shall be provided with a test pushbutton to test relay, operation.

8. Relay shall be powered by 125 V dc control power.

9. Relay ground shall be connected to the enclosure ground bus (not directly to the round grid).

J. DC Voltage Transducers:

1. DC voltage transducers shall be insulated for operation at 4600 V dc for 1 minute. The operating input range shall be 0 to 1500 V dc.

2. The maximum allowable error shall not exceed plus or minus 0.5 percent of full scale at 77 degrees Fahrenheit. Temperature coefficient shall not exceed plus or minus 0.04 percent per each degree Fahrenheit. Load resistance variations from 0 to 10,000 ohms shall affect the output current no more than 0.1 percent.

3. The input circuit shall be completely isolated from all other circuits and grounds. The output circuit shall include internal filtering.

4. Zero and gain adjustments shall be accessible from outside the case.

5. Shall have capability to provide MFPR with de-energization of contact rail on load side of dc breaker.

K. Control Power Requirements:

1. Control power for the ac-to-dc conversion assemblies shall be at 125 V dc, obtained from the control power battery and accessories specified. See Section 34 20 45 – DC Control Power Systems.

2. A double-pole, pullout fuse block shall be provided at each rectifier enclosure. The device shall effectively isolate the conversion assembly relays and protective devices from the power source.

3. A control power voltage monitoring relay manufactured by Potter and Brumfield type CSL38-60010, or Agastat relay, or approved equal shall be provided and connected to the incoming line terminals of the 125 V dc control power bus. Relay shall be set to drop out at 90 V or below and shall initiate local and remote supervisory annunciation.

L. Rectifier Accessories: Manufacturer’s recommended Maintenance accessories and spare parts shall be furnished in accordance with the General Conditions requirements.
M. Space Heaters: Furnish thermostatically controlled adequately sized space heaters to prevent moisture contamination of the internal components within the enclosure. See Section 34 20 50 – Miscellaneous Materials and Devices, for further requirements.

2.03 INITIAL PROVISIONING
A. Each complete traction rectifier assembly shall be provided with an itemized list of parts with quantities, order preference, and price that the Contractor recommends for 2 years of operation before restocking. The reference number for each item shall include the Contractor’s and the original manufacturer’s part numbers. See Technical Provision TP-03, “O&M Performance Requirements” for further requirements.

2.04 SUPERVISORY CONTROL AND ANNUNCIATION REQUIREMENTS
A. Remote supervisory control and annunciation circuits shall be provided between each ac-to-dc conversion assembly and the substation PLC/Annunciator panel. See Section 34 20 35 – Control and Annunciation System, and the RFP Plans for further requirements.

PART 3 – EXECUTION

3.01 INSTALLATION
A. Install the rectifier and the bus assemblies within each substation enclosure secure, plumb, level, and in true alignment with related adjoining work. The rear compartment openings shall be in alignment with enclosure’s exterior access doors.

3.02 TESTING
A. See Section 34 20 80 – Traction Electrification System Testing, for further requirements for the traction rectifier.
B. See Technical Provision TP-02, “Verification Testing and Acceptance” for further requirements.

END OF SECTION
SECTION 34 20 25
DC SWITCHGEAR

PART 1 – GENERAL

1.01 SUMMARY

A. Description: The Work of this Section includes providing metal enclosed dc power switchgear assemblies and associated accessories.

B. Section Includes:
   1. DC Switchgear
   2. DC Power Circuit Breakers
   3. Relays
   4. Lockout Relays
   5. Instruments
   6. Switchgear Maintenance Accessories
   7. Initial Provisioning
   8. Supervisory Control and Annunciation Requirements

C. Related Sections:
   1. Section 34 20 01 – Traction Electrification – General Requirements
   2. Section 34 20 18 – Traction Electrification System MSF Grounding Requirements
   3. Section 34 20 19 – Traction Electrification System Grounding Requirements
   4. Section 34 20 35 – Control and Annunciation System
   5. Section 34 20 45 – DC Control Power System
   6. Section 34 20 50 – Miscellaneous Materials and Devices
   7. Section 34 20 80 – Traction Electrification System Testing.

1.02 PRICE AND PAYMENT PROCEDURES

A. General: Separate measurement or payment will not be made for the Work required under this Section. All cost in connection with Work specified herein will be considered to be included with the related item of work in the General Conditions requirements, or incidental to the Work.

1.03 COEDS, STANDARDS, AND RECOMMENDED PRACTICES

A. American National Standard Institute (ANSI):
   1. ANSI C37.14 Standard for Low-Voltage DC Power Circuit Breakers Used in Enclosures
   2. ANSI C37.16 Preferred Ratings, Related Requirements and Application Recommendations for Low-Voltage Power Circuit Breakers
3. ANSI C37.17  Trip Devices for AC and General Purpose DC Low-Voltage Power Circuit Breakers
4. ANSI C62.1  Standard for Gapped Silicon-Carbide Surge Arresters for AC Power Circuits

B. Institute of Electrical and Electronics Engineers (IEEE):
   1. IEEE C37.20.1  Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear
   3. IEEE 316  Standard Requirement for Direct Current Instrument Shunts

C. National Electrical Manufacturers Association (NEMA):
   1. NEMA BU 1  Busways
   2. NEMA CC 1  Power Connections
   3. NEMA ICS 1  General Standards for Industrial Controls and Systems
   4. NEMA ICS 2  Industrial Control Devices, Controllers and Assemblies
   5. NEMA ICS 6  Enclosures for Industrial Controls and Systems
   6. NEMA SG 3  Low-Voltage Power Circuit Breakers
   7. NEMA SG 5  Power Switchgear Assemblies

1.04 PERFORMANCE REQUIREMENTS

A. The integrated lineup of dc switchgear shall be adequately designed and sized and coordinated with the other components to be installed within the Prefabricated Enclosure as indicated on the RFP Plans.

B. It is the responsibility of the Core Systems Design-Build-Operate-Maintain (DBOM) Contractor to provide coordination with the suppliers of these equipments that a complete and operable system is procured and installed to meet the intent and operation of these Specifications and as indicated in the RFP Plans.

C. Protective relay devices shall be installed in their cases prior to final inspection and shipment.

D. Circuit breaker tripping shall not be affected by the position of the TPSS and GBS master Remote/Local Selector switch specified in Section 34 20 35 – Control and Annunciation.

E. As indicated in the RFP Plans, the mainline substation Waipahu TPSS shall have the capability to feed the MSF Yard traction power in case the Yard TPSS is out-of-service through the operation of the positive feeder breaker B06 and negative B08 breaker at the Waipahu TPSS. The sequence of operation shall meet the following objectives as herein described.

   1. Breakers B06 and B08 shall be normally in the open position (with the Yard TPSS in service).
2. When the MSF Yard is to be energized from mainline substation Waipahu TPSS because the Yard TPSS is out-of-service, B06 and B08 breakers in the Waipahu TPSS shall be closed.

3. The negative breaker B08 shall be interlocked with the positive breaker B06 so that closing breaker B06 automatically and simultaneously closes breaker B08. And vice versa, opening breaker B06 also automatically and simultaneously opens breaker B08.

F. As indicated in the RFP Plans, a “kicker” contact rail section is a very short section that bridges two adjacent normal-length contact rail sections. The purpose of the kicker rail is to avoid a non-bridgeable contact rail gap in the path of an accelerating train under normal conditions. The “kicker” rail feeder breaker shall be interlocked with the feeder breakers of the two adjoining contact rail sections in such manner that opening of one of those feeder breakers results in automatic opening of the breaker of the "kicker" rail section. Such action will result in the creation of a non-bridgeable contact rail gap between the two main sections, one of which is de-energized. The following additional interlocks shall be provided for the circuit breaker of the "kicker" rail section:
   1. The “kicker” rail breaker cannot be closed if either of the associated breakers (controlling the adjacent main sections) is open.
   2. The "kicker" rail breaker can be open at any time without affecting the associated feeder breakers.

G. See Section 34 20 01 – Traction Electrification General Requirements, for abbreviations, definitions, device requirements and further requirements of the TES equipment.

1.05 SUBMITTALS

A. General: Refer to General Conditions requirements for Submittal Procedures, and for Shop Drawings, Product Data, and Samples requirements and procedures.

B. Submit all data, design plans, procedures and samples in accordance with the requirements of Section 34 20 01 – Traction Electrification - General Requirements, including, but not limited to the following:
   1. Manufacturer’s product descriptions, catalog data, and information.
   2. Manufacturer’s general arrangement and detail drawings for each type of switchgear assembly and prime components.
   3. Manufacturer’s arrangement and detail drawings.
   4. Equipment schematic, wiring and interconnection diagrams.
   5. Operation and maintenance manual, including spare parts list.
1.06 QUALITY ASSURANCE
   A. General: Refer to General Conditions requirements for quality assurance requirements and procedures.
   B. Comply with all applicable Federal, State, and Local Laws, Regulations, and Codes including those referenced in Article 1.03.

1.07 DELIVERY, STORAGE AND HANDLING
   A. As the DC Switchgear is installed within the Prefabricated Enclosure, the Core Systems DBOM Contractor shall coordinate the delivery, storage and handling of the DC switchgear with the requirements as described in Section 34 20 05 – Prefabricated Enclosures.

1.08 WARRANTY
   A. The Core Systems DBOM Contractor suppliers shall warrant that their products are free from defects. Warranty shall conform to the requirements of the General Conditions requirements.

PART 2 – PRODUCTS

2.01 DC SWITCHGEAR
   A. Type:
      1. The switchgear assemblies shall comply with the requirements given in ANSI C37.20.1, NEMA SG 5, and shall form a lineup of dead-front, freestanding, indoor sheet-steel enclosures. Enclosures shall be designed for high-resistance grounding system.
      2. Each switchgear assembly shall include draw-out type, single-pole, dc power circuit breakers, dc positive buses and bus connections, indicating lights, terminal blocks, protective and auxiliary relays, control circuitry, wiring, and all other devices necessary to make a complete and operable assembly. The assembly shall comply with NEMA ICS 1, ICS 2 and ICS 6 standards.
   B. The height of components, relays, and devices installed in or on the switchgear assembly, which require servicing, maintenance, or adjustment, shall be limited to 6 feet 6 inches above floor level. Such components, relays and devices shall be accessible from the front of the lineup. Ratings: The switchgear assemblies shall have the following ratings and requirements:
      1. Nominal Voltage: 775 V dc
      2. Maximum Operating Voltage: 950 V dc
      3. Rated Bus Continuous Current, rms, amperes: 6,000
      4. Rated Bus Momentary Current, amperes (minimum): 100,000
      5. Power Frequency Withstand Insulation Level, kV, rms, (minimum): 4.2
      6. The switchgear assembly for each substation shall be comprised of the number of circuit breakers as indicated on the RFP Plans
C. Circuit Breaker Compartment:
   1. A separate metal-enclosed compartment shall be provided to house each draw-out type circuit breaker element. Guide rails or cradles for positioning the removable element shall be provided as an integral part of the compartment.
   2. Means shall be provided for positively holding the circuit breaker element in place in the housing when the removable element is in the CONNECTED or TEST position. Positive acting mechanical and electrical interlocks shall be provided to prevent incorrect movement of a CLOSED circuit breaker to or from the CONNECTED position and to prevent electrical closing of the circuit breaker within the compartment except in the CONNECTED or TEST position.
   3. Interlocks shall be provided on the units where the relay/metering compartment and circuit breaker compartment are separate so that when a circuit breaker is in the CONNECTED position, the breaker cannot be closed when the door is open and, like wise, the door cannot be opened when the circuit breaker is closed.
   4. On units where the entire cubicle including relays, meters etc. are mounted on a removable mechanism, interlocks shall be provided such that the circuit breaker cannot be CONNECTED unless the circuit breaker is fully inserted or removed unless the breaker is OPEN.
   5. Each circuit breaker compartment shall be furnished with line-side and load-side, self-aligning, primary disconnecting contacts. The devices shall be suitably shrouded or provided with automatic safety shutters to prevent accidental contact with live parts.
   6. Circuit breaker compartments shall only permit the interchange of circuit breaker removable elements of the same type and rating.

D. Dimensions and Arrangement:
   1. The dimensions and arrangement of the indoor switchgear shall allow adequate clearance to ground and for the dissipation of ionized gases from the breaker arc chutes without hazard to personnel or possibility of establishing a conducting path to a grounded structure or objects when interrupting rated short circuit current at rated maximum voltage.
   2. Adequate provisions shall be made for release of gases from the units by means of suitable stacks, louvered vent openings, or vent openings covered with grilles, arranged such that hot gases or other materials cannot be discharged in a manner hazardous to personnel. The design for venting all dc circuit breaker cubicles shall be such that under fault conditions, the breakers, which will experience extreme interrupting duty, shall accomplish this task without damage to the switchgear structure.

E. Doors and Panels for Fixed Mounted Relays, Devices, and Meters:
   1. Each circuit breaker compartment shall be furnished with a formed hinged door on the front of the structure to cover the compartment opening. The door shall be provided with a handle and lockable latch. Door stops shall hold the door in open position and provide unhindered withdrawal of the circuit breaker removable element from the compartment.
   2. Relays, instruments, and control devices shall be mounted on the formed hinged panels and furnished with handle and latch. A stop shall hold panel in open position.
3. Removable, bolted metal or plastic covers shall be furnished to provide access to the bus and feeder cabling compartments.

F. **Main Bus and Connections:**

1. DC switchgear positive bus shall be furnished for the full length of the switchgear assembly and shall be made of electrical grade copper. The bus shall be fully insulated over its entire length with flame retardant, non-hygroscopic, track-resistant insulation. The bus and bus connections shall be of adequate strength to withstand thermal and mechanical stresses associated with short circuit currents as specified above. Stand-off bus insulators shall be molded epoxy or porcelain construction. The bus and connections shall comply with NEMA BU 1 and NEMA CC 1 standards, respectively.

2. The dc bus overload rating shall be coordinated with that of the rectifier units without exceeding the permitted hottest-spot temperature rise.

3. Bus connections, including bus taps, shall be silver-plated. Each main bus joint shall have conductivity at least equal to that of the bus bar and each joint shall be constructed so that no loss of conductivity will occur during the life of the switchgear. Connections to the bus shall be bolted. The bolts shall be cadmium-plated, galvanized, or similarly coated, high-strength steel, and of sufficient number and size to provide solidly bolted connections.

G. **Control Power Bus:**

1. A 125 V dc control power bus with 2,000 V dc insulation level shall be furnished the full length of the switchgear assembly for circuit breaker control operation. Control power for the switchgear will be provided from the control power dc Power Panel specified in Section 34 20 45 – DC Control Power System.

2. A double-pole, pullout fuse block shall be provided at each circuit breaker compartment. The device shall effectively isolate the operating mechanism from the control bus.

3. A control power voltage monitoring relay, Potter and Brumfield type CSL-38-60010 or, Agastat relay or, approved equal shall be provided, and connected to the load side terminals of each pullout fuse block. Relay shall be set to drop out at 90 V or below and shall initiate local and remote supervisory annunciation.

H. **Cable Terminations:** Each switchgear assembly shall have adequate space for termination of power cables to feeder circuit breakers as indicated. Necessary means for supporting and connecting the cables at the terminals shall be furnished. The cable entry cover plate shall be bolted to permit field drilling of holes for conduit entry.

I. **Space Heaters:** Each switchgear assembly shall be furnished with thermostatically controlled adequately sized space heaters to prevent moisture contamination of the internal components. See section 34 20 50 – Miscellaneous Materials and Devices, for further requirements.

J. **Surge Arresters:**

1. Compartment-mounted, indoor style, metal oxide surge arresters shall be furnished for the feeder circuit breaker units. High Rupture Capacity fuses with micro switch for blown-out fuse indication shall be provided in series with each arrester to protect the arrester from exploding due to short circuit.
2. Arresters shall be designed, constructed, and tested in accordance with the general requirements of ANSI C62.1. Arresters shall be suitable for connection to 800-V dc nominal power supply for protection of the dc power switchgear against lightning surges.

3. Provide arresters having minimum dc and maximum peak sparkover voltage ratings, and residual voltage values as coordinated with the dc voltage operating parameters, the dielectric withstand voltage characteristics of the switchgear bus, and circuit breaker insulation structure.

4. Cable connection between the surge arrester and the load side of the feeder circuit breaker shall be kept as short as possible and sufficient clearance from metallic parts shall be maintained. Cable connection to the surge arrester shall be taped.

5. Ground Bus: The dc switchgear shall be furnished with an isolated insulated low resistance copper ground bus for directly connecting the surge arrester ground terminals. Each end of the ground bus shall be provided with terminal lug suitable to accommodate #4/0 AWG grounding insulated copper cable connected to substation ground grid.

### 2.02 DC POWER CIRCUIT BREAKERS

A. Circuit breakers shall comply with the requirements given in ANSI C37.14, 37.16, 37.17 and NEMA SG 3, and as specified.

B. Type and Ratings:

1. Type:
   a. The low-voltage power circuit breakers shall be direct current, air-break, and single-pole, high-speed, draw-out type. Circuit breakers shall be electrically operated, suitable for local and remote supervisory control and provided with trip devices specified.
   b. Circuit interruption arc chutes shall be suitable for bidirectional current flow and designed for positive interruption of all currents within the circuit breaker ratings. Arc chutes shall be furnished with air puffer device to positively extinguish low current arcs within the arc chute.

2. Ratings: Circuit breakers shall be certified for use on transit systems consisting of a contact rail system. Circuit breakers shall have the following minimum required capabilities, as defined in ANSI C37.14, and based on test values given in ANSI C37.16, Table 11.
   a. Rated Continuous Current, rms, amperes: 4000
   b. Maximum Operating Voltage: 950 Vdc
   c. Power Frequency Withstand Insulation Level, kV, rms: 4.2
   d. Short Circuit Interruption Capabilities: Per ANSI C37.16

C. Insulation Structure: Materials shall be of types that are noncombustible, nonhydroscopic and tracking resistant. The mechanical strength and physical characteristics of the insulation structure shall match the stresses imposed by circuit breaker rated momentary current.
D. Removable Assembly:
   1. The circuit breaker removable elements shall be truck or cradle mounted with
      handles and suitable for manual removal and insertion of the assembly out of and
      into the stationary compartment.
   2. The removable assembly shall be provided with a fully interlocked, manually
      operated racking mechanism to move the circuit breaker between TEST and
      CONNECTED positions. A clearly visible position indicator shall be provided.
   3. The circuit breaker primary disconnecting contacts shall be comprised of heavy-
      duty, self-aligning, spring-loaded, silver-plated, copper disconnect fingers that
      engage with the line-and load-side stationary disconnecting contacts.
   4. Circuit breaker control wiring connections between removable element and
      stationary compartment shall have provisions for maintaining, or automatically
      reinstating, circuit continuity when the removable element is moved between the
      CONNECTED and TEST positions within the compartment. Means shall be
      provided for simultaneous disconnection of control wiring connections when the
      removable element is moved to a disconnected position.

E. Operating Mechanism:
   1. The circuit breakers shall be quick-make and quick-break, and shall be furnished
      together with a mechanism to provide full contact pressure until the time of
      opening.
   2. All breakers shall be electrically operated, mechanically latched, and electrically
      and mechanically trip-free, and shall have control circuits connected in a manner
      to make the mechanism non-pumping.
   3. The operating mechanism shall be furnished with mechanical indicators to show
      the OPEN and CLOSED positions of the main moving contacts.
   4. Each mechanism shall be provided with a no resettable register type operation
      counter to record each circuit breaker close/open cycle.
   5. The dc feeder circuit breaker shall be provided with device No. 176
      (bi-directional) direct-acting, instantaneous series, overcurrent trip, set to trip the
      feeder breaker (device No. 172) on heavy overcurrent or short circuit. The device
      shall be adjustable between 100 and 400 percent of continuous current rating of
      the breaker.
   6. Each cathode circuit breaker closing mechanism shall be furnished with a unique
      key interlock coordinated with the associated rectifier negative disconnect switch.
      The interlock system shall prevent closing of the circuit breaker unless the
      disconnect switch is closed and shall prevent the opening of the disconnect switch
      unless the circuit breaker is open.
   7. Circuit breaker operating mechanisms shall be furnished with two spare Forms A
      and two spare Form B electrically isolated auxiliary switch contacts and a
      minimum of two extra "a" and "b" contacts to indicate the open or closed
      condition of the breaker. Contacts shall be wired to terminal blocks in low-
      voltage compartment for electrical interlocking of associated power switching
      devices, as indicated.
F. Circuit Breaker Control:
   1. The circuit breaker shall be designed for both local and remote supervisory electrical operation at 125 V dc nominal control power supply.
   2. The closing mechanism shall be suitable for operation over a voltage range of 100 to 140 V dc. The tripping mechanism shall be suitable for operation over a voltage range of 70 to 140 V dc.

G. Load Measuring Components:
   1. Each feeder circuit breaker shall be furnished with an automatic reclosing and load measuring contactor device No. 129, including load measuring resistors, fuses, and associated accessories.
   2. See Multifunction Relay as described in Article 2.03G herein, for further requirements of the load measuring components.

2.03 RELAYS

A. Switchgear assemblies shall be furnished with relaying systems and related functions as indicated in the RFP Plans and as further specified herein.

B. Additional components, such as auxiliary relays, isolating diodes, and other devices not indicated but required for a complete fully functional system, shall be furnished and installed.

C. Each relay shall have a sealed dust cover that shall keep the inside of the case free of dust and moisture.

D. Control and auxiliary relays shall be electro-mechanical type. Solid-state type auxiliary relays are acceptable provided their output contacts, if required to interface with other systems such as the Programmable Logic Controller (PLC) are independent and potential free.

E. Unless stated otherwise, relays requiring control power shall be able to operate properly with station battery voltage varying at least between 125 V dc plus 10/minus 15 percent V dc.

F. All relay contacts shall be correctly rated for the intended duty, and shall meet the required performance with no less than 50 percent spare margins at the worst-case scenario.

G. DC Multifunction Protection Relay (MFPR) requirements:
   1. The protective relay located in the dc switchgear compartments shall be a solid-state integrated relay package with programmable multifunction’s with self-checking features.
   2. The relays shall be built to operate in a hostile harsh environment utilizing conformally coated circuit boards to protect them from moisture, temperature variations, salt spray, organic attack (fungus), and aggressive chemicals and vapors.
      a. The relay shall be provided for flush or semi-flush mounting on doors. They shall be of drawout construction to facilitate testing, maintenance and interchange flexibility.
      b. It shall have an operator interface located on the exterior door of the associated dc feeder breaker control compartment.
c. The operator interface shall be a large character display, with navigation keys, and a full numeric keypad.

d. Indicator light emitting diodes on the front panel shall provide a quick visual indication of status.


4. An isolated high voltage signal measurement transducer located in the associated dc feeder bus compartment:
   a. Connection between signal collection equipment and dc MFPR located in the control compartment shall use a fiber optic connection to a transducer. Any detected transducer or fiber optic cable malfunction shall initiate a dc MFPR trouble indication. Fiber optic cable shall be sufficiently rugged to withstand all expected thermal, mechanical, and electrical stresses.
   b. Shunts shall be used to obtain required current and voltage. Hall Effect type sensors are not acceptable.
   c. Provide any required bleeder resistors between dc positive and negative buses and voltage transducer to ensure adequate filtering of random transient voltages inherent in traction power rectifiers and dc switchgear.

5. The relay shall be provided with application software, windows based, and provided on CD or DVD type media. All programs licenses shall become the property of the City. Any required programming cables shall be provided.

6. Data logging capabilities shall include the following:
   a. Retain in non-volatile memory oscillogram type records of voltage and current traces.
   b. Retain records of trips and/or alarms with date/time stamps. All trip events, failures to reclose, and system malfunctions shall be included among the alarms.
   c. Retain in non-volatile memory program, alarm log, and recorded data traces.

7. Remote Communications: Provide remote communication links to the master PLC as specified in Section 34 20 35 – Control and Annunciation System, including RS-232 and RS-485 communications ports enabling the following remote user capabilities.
   a. View and configure all dc MFPR functions and parameters.
   b. View and retrieve all alarm log and stored data traces.
   c. View system diagnostics and status indications.
   d. Download dc MFPR operating software.
   e. Ability to use the Special Tools as required and defined in Section 34 20 01 – Traction Electrification - General Requirements.

8. The dc MFPR functions shall include the following:
   a. Short Circuit Protection:
      1) Instantaneous Overcurrent Trip No 176F
      2) Low Level Fault Trip
      3) Overload of positive feeder cable No 151F
      4) Timed Overcurrent Trip
      5) Rate of Rise Trip No 150F
6) Transfer Trip No 185
b. Automatic Reclosing System Logic:
   1) Automatic reclosing to operate external device No. 129
   2) Load measuring No.’s 182/183
c. Contact Rail Potential Indication:
   1) The contact rail potential function shall be fail-safe, such that if the
      function or input measurement fails, it shall indicate that the contact rail
      is energized.

9. Relay Outputs: Provide contacts for breaker close, load measurement contactor
   (device No. 129) control, system trouble/loss of control power, instantaneous
   overcurrent trip, and timed overcurrent trip as a minimum interfacing output
   contacts.

10. Data Inputs: Provide closed command (coming from local or remote), trip
     command (coming from local or remote), trip-reclose command (coming from
     PLC for transfer trip system), breaker auxiliary contact, breaker position contact,
     and general purpose programmable inputs.

11. Meters: The Multifunction Relay shall perform dc voltage and amperage display
     as indicated on the RFP Plans:
     a. Ammeters as indicated shall have an overload capacity for repeated
        overcurrents of up to 450 percent of scale range
     b. Voltmeters as indicated from voltage transducer
     c. Remote Data to the PLC shall also be provided for analog display and data
        manipulation for dc amps and dc Volts as indicated in the RFP Plans

12. The Core Systems DBOM Contractor shall be responsible for the final setting of
     relaying systems to be established during integrated system tests in the field. See
     Section 34 20 80 – Traction Electrification System Testing and Technical
     Provisions TP-02 for verification testing and acceptance.

H. Enclosure Ground /Alive (Hot Structure) Relaying: Grounding shall be provided in
   accordance with High or Low resistance design as in conformance with the design
   criteria of this DBOM Contract and as follows:

1. The dc switchgear enclosure shall be insulated from the substation enclosure floor
   and any adjacent grounded surfaces. Enclosure ground bus shall be single point
   grounded by means of an insulated # 4/0 AWG copper conductor connected
   directly to the substation buried ground grid as indicated in the RFP Plans. See
   Section 34 20 18 – Traction Electrification System MSF Grounding Requirements
   and Section 34 20 19 – Traction Electrification System Grounding Requirements,
   for further requirements.

2. Provide a dual function adjustable instantaneous ground and active relay device
   No. 164G/A. Relays shall initiate local and remote supervisory annunciations.
   The relay shall interface with the PLC as described in Section 34 20 35 – Controls
   and Annunciations. The PLC shall be provided with logic to trip the lockout
   relay, device/function No. 186.

3. For positive to enclosure energized dc switchgear hot structure (Alive) faults the
   entire TPSS facility shall be de-energized through tripping of the 186 function.

4. For enclosure exposed to ground type faults, provide alarm only.
5. Relays shall have inverse time delayed detection after the set value is reached. The relay shall have adjustable setting ranges for the 64 Ground function and 64 Alive function.

6. The grounding system relaying shall be designed to operate without damage when maximum system fault current flows to ground for the time required clearing the fault.

7. Relays shall have self-monitoring fail-safe annunciation features. They shall be provided with test pushbutton to test relay operation.

8. Relay shall be powered by 125 V dc control power.

9. Relay ground shall be connected to the enclosure ground bus (not directly to the ground grid).

I. Automatic Reclosing and Load Measuring Operation:

1. Upon transfer tripping command, through the multifunction relay, immediate operation of its load measuring devices for automatic reclosure shall be initiated.

2. The load measuring and automatic reclosing cycle shall be initiated when either the associated feeder circuit breaker receives a CLOSE signal from the PLC via the Multifunction Relay, or the local close control switch, the circuit breaker is tripped automatically by the feeder circuit protection, or transfer trip operation.

3. Initiation of the load measuring cycle shall be preceded by an adjustable time delay to permit the faulted Contact Rail System section to become fully de-energized. At the commencement of the load measurement cycle, determination of whether there is no voltage on the section or if there is voltage present due to reclosing of the remote feeder circuit breaker shall be initiated.

4. If the voltage measuring circuit detects potential on the section, it shall reclose the associated circuit breaker, provided that this potential is greater than a preset value. Pickup adjustment range shall cover a minimum voltage for train operation as described in the Design Criteria Chapter 12 Passenger Vehicles and the Passenger Vehicle Technical Provisions.

5. If the voltage measuring circuit detects no potential on the section, the load measuring cycle shall be initiated. Load measuring shall continue to be made at suitable adjustable time intervals. If any load measurement determines that no fault is present, automatic reclosing of the circuit breaker shall be initiated. A successful reclosure, with no subsequent automatic trip shall complete the load measurement cycle and reset the load measurement components to their initial state.

6. Provisions shall be made for selection of up to three circuit breaker reclosure cycles at adjustable intervals, within an adjustable time. If no successful reclosure takes place in this time, the automatic reclosing and load measuring system shall lock out, and initiate remote annunciation, until a further circuit breaker CLOSE signal is received from the multifunction relay via the PLC or by operation of a manual RESET pushbutton at the MFPR and Liquid Crystal Display (LCD) screen.

7. Each automatic reclosing and load measuring system shall be furnished with test facilities that shall check the functioning of all components of the system. The test cycle shall be initiated by a local TEST pushbutton, but shall not close the circuit breaker when the removable element is in the CONNECTED position.
8. The load measuring circuit shall compensate for pre-existing (rail drop) voltage and shall preclude closing on a fault at any pre-existing voltage.

J. Substation Cathode Breaker Relaying:
   1. Provide reverse current instantaneous trip relay, device No. 132 with a pickup setting of 50 percent maximum of rated current. The cathode breaker reverse current relay shall interface with the PLC as described in Section 34 20 35 – Controls and Annunciations. Device No. 132 shall initiate local and remote supervisory announcements as indicated in the RFP Plans. The PLC shall be provided with logic to trip the lockout relay, device No. 186 upon initiation of this reverse current trip setting.
   2. The PLC shall also have the ability to control the cathode breaker (B0-1) device No. 172-1 for Open and Close operations as indicated in the RFP Plans.

2.04 LOCKOUT RELAYS
   A. Lockout relays shall be high-speed, multi-contact, hand reset type with oval handles and mechanical targets that indicate whether the relays are in the tripped or reset position.
   B. Lockout relays shall be General Electric Type HEA, Westinghouse Type WL, or equal.
   C. Lockout relay trip unit, device 186, shall be located on the front face of the cathode breaker cubicle.
   D. The PLC shall operate the lockout relay, device/function No. 186, and shall trip the dc cathode breaker as indicated in the RFP Plans.
   E. If the Core Systems DBOM Contractor chooses to implement the lockout feature under software logic through the TPSS and GBS PLC system as specified in Section 34 20 35 – Control and Annunciation Systems, a manual reset shall be required at the PLC/Annunciator panel.
   F. Provide 186 device lockout trip contacts for connection to the PLC for alarm at the LCD screen.

2.05 INSTRUMENTS
   A. Switchgear assemblies shall be furnished with instruments and accessories, as indicated on the RFP Plans:
      1. DC shunts shall be provided to interface isolating transducers for all dc multifunction relays. Control wiring associated with the shunts shall be housed in a separate non-metallic trough. Wire terminating to the devices shall be covered with insulating boots.
      2. Isolated voltage transducer with Voltmeters scaled as indicated shall be provided for the dc bus voltage.
      3. Control devices, instruments, and circuits, whether mounted on the compartment door or other position of the stationary unit structure, must be physically accessible and so connected as to permit safe testing and/or maintenance of relays.
      4. Ammeter shunts shall comply with IEEE 316 and have a rated output consistent with the input requirements of the transducer and the Multifunction Relay requirements.
B. DC Voltage Transducers:
   1. DC voltage transducers shall be insulated for operation at 4600 V dc for 1 minute. The operating input range shall be 0 to 1500 V dc.
   2. The maximum allowable error shall not exceed plus or minus 0.5 percent of full scale at 77 degrees Fahrenheit. Temperature coefficient shall not exceed plus or minus 0.04 percent per each degree Fahrenheit. Load resistance variations from 0 to 10,000 ohms shall affect the output current no more than 0.1 percent.
   3. The input circuit shall be completely isolated from all other circuits and grounds. The output circuit shall include internal filtering.
   4. Zero and gain adjustments shall be accessible from outside the case.
   5. DC voltage transducers shall have capability to provide MFPR with de-energization of contact rail on load side of dc breaker.
   6. Isolation transducers shall be either 4 to 20 mA, or 1 to 5 V signals.

2.06 SWITCHGEAR MAINTENANCE ACCESSORIES
A. Each switchgear assembly shall be provided with the following:
   1. One circuit breaker test cabinet, wall-mounted, complete with test jumper cables and connectors
   2. One set of circuit breaker removal accessories, including lifting and handling devices

2.07 INITIAL PROVISIONING
A. Each complete dc Switchgear assembly shall be provided with an itemized list of parts with quantities, order preference, and price that the Contractor recommends for 2 years of operation before restocking. The reference number for each item shall include the Contractor’s and the original manufacturer’s part numbers. See Technical Provision TP-03, “O&M Performance Requirements” for further requirements.

2.08 SUPERVISORY CONTROL AND ANNUNCIATION REQUIREMENTS
A. Supervisory control and annunciation circuits shall be provided for the dc switchgear and interface with the substation PLC/Announcer panel. See Section 34 20 35 – Control and Annunciator System, and the RFP Plans for further requirements.
   1. DC Switchgear Control Circuits:
      a. Cathode circuit breaker - OPEN
      b. Cathode circuit breaker - CLOSE
      c. Feeder circuit breaker - OPEN
      d. Feeder circuit breaker - CLOSE
   2. Local Status Indication Circuits on each dc Switchgear:
      a. Cathode circuit breaker - OPEN
      b. Cathode circuit breaker - CLOSED
      c. Feeder circuit breaker - OPEN
      d. Feeder circuit breaker - CLOSED
e. TPSS master Local/Remote Switch Indication:
   1) Local Indication - Amber
   2) Remote Indication - Blue

B. Remote supervisory Status and Annunciation Circuits:
   1. Cathode circuit breaker - TRIPPED
   2. Feeder circuit breaker - TRIPPED
   3. Transfer Trip System - Trouble
   4. Feeder Breaker Re-Closure - Failure
   5. Feeder Breaker Multi-Function Relay - Trouble
   6. DC Switchgear Enclosure - Alive
   7. DC Switchgear Enclosure - Grounded
   8. Contact Rail Energized - (Each Electrical Section)
   9. Lockout relay 186 - Tripped

C. Analog Indication Circuits: 0 to 1,000 V dc, by output signal from dc voltage transducers with 0 to 1,000 V dc input range.

D. The MFPR shall be integrated with the Master PLC located in the PLC/Annunciator panel through a local area network. See Section 34 20 35 – Control and Annunciation System, for further requirements.

PART 3 – EXECUTION

3.01 INSTALLATION
   A. Install the dc power switchgear within the substation enclosure secure, plumb and level and in true alignment with related adjoining work. Switchgear rear compartment openings shall align with enclosure exterior access doors.

3.02 TESTING
   A. Testing shall be provided in accordance with Section 34 20 80 – Traction Electrification System Testing.
   B. See Technical Provision TP-02, “Verification Testing and Acceptance” for further requirements.

END OF SECTION
SECTION 34 20 30
NEGATIVE GROUNDING DEVICE

PART 1 – GENERAL

1.01 SUMMARY

A. Description: The Work of this Section includes the requirements for the procurement and installation of the negative grounding device (NGD). The Work includes providing all components and assemblies necessary to provide for the NGD within the Prefabricated Enclosure Traction Power Substation (TPSS) and Gap Breaker Station (GBS) for controlling rail to ground potentials.

B. Section Includes:
   1. Main Components
   2. Operational Requirements
   3. Control Equipment
   4. Reliability
   5. Cabling and Terminal Connections
   6. Initial Provisioning
   7. Supervisory Control and Annunciation Requirements

C. Related Sections:
   1. Section 34 20 01 – Traction Electrification - General Requirements
   2. Section 34 20 05 – Prefabricated Enclosures
   3. Section 34 20 20 – Traction Rectifier
   4. Section 34 20 35 – Control and Annunciation System
   5. Section 34 20 80 – Traction Electrification System Testing

1.02 PRICE AND PAYMENT PROCEDURES

A. General: Separate measurement or payment will not be made for the Work required under this Section. All cost in connection with Work specified herein will be considered to be included with the related item of work in the General Conditions requirements, or incidental to the Work.

1.03 CODES, STANDARDS, AND RECOMMENDED PRACTICES

A. American National Standards Institute (ANSI):
   1. ANSI C37.14 Low-Voltage DC Power Circuit Breakers Used in Enclosures
   2. ANSI C37.16 Preferred Ratings, Related Requirements and Application. Recommendations for Low-Voltage Power Circuit breakers
   3. ANSI C37.20.1 Metal Enclosed Low-Voltage Power Circuit Breakers Switchgear
4. ANSI C37.90.1 Surge Withstand Capability
5. ANSI C62 Surge Arresters for Protection Standards Collection

B. ASTM International (ASTM):
1. ASTM B3 Specifications for Soft or Annealed Copper Wire
2. ASTM B8 Specified for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
3. ASTM B33 Specifications for Tinned Soft or Annealed Copper Wires for Electrical Purposes
4. ASTM B187 Copper Bus Bar, Rod and Shapes

C. Federal, State, and Local Jurisdictions:
1. All Applicable Codes, Ordinances, and Regulations

D. Institute of Electrical and Electronic Engineers (IEEE):
1. IEEE 80 Guide for Safety in Alternating Current Substation Grounding
2. IEEE 81 Ground Resistance and Potential Gradients in the Earth, Recommended Guide
3. IEEE 141 Recommended Practice for Electric Power Distribution for Industrial Plants
4. IEEE 142 IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems
5. IEEE 143 Guide for Application of Neutral Grounding in Electrical Utility Systems
6. IEEE 316 Direct Current Instrument Shunts
7. IEEE 837 Standard for Qualifying Permanent Connections Used in Substation Grounding
8. IEEE C2 Grounding Requirements of the National Electrical Safety Code (NESC)

E. National Electrical Manufacturers Association (NEMA):
1. NEMA SG 3 Low-Voltage Power Circuit Breakers
2. NEMA SG 5 Power Switchgear Assemblies
3. NEMA 250 Enclosures for Electrical Equipment 250, Type 12

F. National Fire Protection Association (NFPA):
1. NFPA 70 National Electrical Code
2. NFPA 780 Lightning Protection Code
3. NFPA 130 Fixed Guideway Transit Systems

G. Underwriters' Laboratories, Inc. (UL):
1. UL 44 Rubber-Insulated Wires and Cables
2. UL 467 Grounding and Bonding Equipment
1.04 PERFORMANCE REQUIREMENTS

A. The NGD shall provide automatic grounding of the negative bus if the negative bus to ground voltage exceeds a preset level of either polarity.

B. The installation of the NGD shall be coordinated with the TPSS and GBS Pre-fabricated enclosure buildings layout and equipment grounding connections as indicated in the RFP Plans. Any Core Systems Design-Build-Operate-Maintain (DBOM) Contractor deviation from the NGD location will be the responsibility of the Core Systems DBOM Contractor to coordinate with the Guideway and MSF Design-Build Contractor for all changes in any of the Prefabricated Enclosure equipment layout and conduit stub up locations.

C. The NGD shall be of the design of a switching element, consisting of thyristor instantaneous trip units. Its thyristor-based assembly shall act as a solid-state switch. The NGD shall also contain voltage and current sensing devices, a microprocessor-based controller, front panel with operator controls, and local and remote indication capability.

D. The NGD shall be connected between the Negative Bus (via a safety disconnect switch) and the TPSS or GBS Ground Grid.

E. The NGD shall provide for prevention against personal injury from impermissible touch voltages due to operational or short-circuit currents in the running rails.

F. The NGD shall be a voltage-limiting device used between the return circuit and the earth to reduce excessively high voltages by temporarily short-circuiting the return circuit to earth.

G. The locations of the devices are as indicated in the Contract Documents.

H. The NGD shall provide automatic grounding of the negative bus if the negative bus to ground voltage exceeds a preset level of either polarity.

1.05 SUBMITTALS

A. General: Refer to General Condition for Submittal Procedures, and for Shop Drawings, Product Data, and Samples requirements and procedures.

B. Submit all data, design plans, procedures and samples in accordance with Section 34 20 01 – Traction Electrification - General Requirements, including, but not limited to the following:

1. Manufacturer’s product descriptions, catalog data, and information.

2. Manufacturer’s general arrangement and detail drawings for each NGD assembly and prime components.

3. Manufacturer’s arrangement and detail drawings.

4. Equipment schematic, wiring and interconnection diagrams.

5. Operation and maintenance manual, including spare parts list.


1.06 QUALITY ASSURANCE
   A. General: Refer to General Conditions requirements for quality assurance requirements and procedures.
   B. Comply with all applicable Federal, State, and Local Laws, Regulations, and Codes including those referenced in Article 1.03.

1.07 DELIVERY, STORAGE, AND HANDLING
   A. As the NGD is installed within the Prefabricated Enclosure, the Core Systems DBOM Contractor shall coordinate the delivery, storage and handling of the NGD with the requirements as described in Section 34 20 05 – Prefabricated Enclosures.

1.08 WARRANTY
   A. The Core Systems DBOM Contractor suppliers shall warrant that their products are free from defects. Warranty shall conform to the requirements of the General Conditions requirements.

PART 2 – PRODUCTS

2.01 MAIN COMPONENTS
   A. The NGD shall consist of a thyristor-based assembly acting as a solid-state switch, voltage and current sensing devices, microprocessor-based controller, front panel with operator controls, and local and remote indication capability. The NGD shall be connected between the Negative Bus (via a safety disconnect switch) and the TPSS or GBS Ground Grid.

   B. The safety disconnect switch shall be manual, single pole, single throw type, with copper blade and silver-plated contacts. The NGD shall comply with applicable NEMA standards as listed in Article 1.03 herein. The switch shall have minimum 1,000 A continuous and 15,000 A momentary current ratings, and 775 V nominal voltage rating. The safety disconnect switch shall be equipped with insulated operating handle and with a solenoid-based interlock to prevent the switch from opening if significant current is flowing in the circuit (that would cause an arc if the switch were to be opened).

   C. The thyristor-based switch of the NGD shall comprise two thyristors connected between the negative bus and the substation ground grid in anti-parallel configuration, which permits one-way-only current conduction in either direction. A thyristor referred herein, is a functional thyristor, meaning one or more physical thyristors connected in parallel depending on the circuit’s ampacity requirements. The thyristors shall be mounted on heat sinks sized in accordance with the required current rating at the maximum ambient air temperature of the substation. Cooling shall be by natural convection.

   D. Determine the momentary and continuous current ratings of the thyristor switch and reverse voltage rating of the thyristors, based on the worst fault NGD exposure conditions. Such conditions shall be assessed considering the possible failure modes of the TPSS equipment and positive-to-ground faults that could occur in the dc distribution system outside the substations. At a minimum, the analysis used to justify the momentary and continuous current ratings of the NGD shall include the following scenarios:
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1. DC surge arrester failure on short inside the TPSS
2. Contact rail ground contact between substations

E. The NGD shall include a voltage sensor as part of the control circuitry. The voltage
sensor shall monitor continuously the potential between the negative bus and ground
and shall be polarity sensitive. If the negative bus potential to ground exceeds the
preset level, the NGD controller shall trigger to close only the appropriate thyristor that
will ground the negative bus.

F. The NGD shall include a sensor for current measurement with a useful range and
accuracy appropriate for the application. The current sensor shall be used to measure
the current passing through either thyristor when the negative bus is grounded.

G. Minimum Electrical Ratings:
1. Maximum system operating voltage: 1,000 V
2. Rated current: As determined by required fault current to be withstood:
3. Rated current short time 0.1 sec: As determined by required fault current to be
   withstood
4. Rated current short time 10 ms: (Peak value sinusoidal half-wave) as determined
   by required fault current to be withstood
5. Mechanical lifespan switching operations: 1.5 million
6. Operating frequency switching operations/hr: 120

H. General Mechanical Ratings:
1. Dimensions (H x W x D): 3 ft Height, 3 ft Width, 1-1/2 ft Depth
2. Color: Conform to Section 34 20 05 – Prefabricated Enclosures
3. NEMA Enclosure Ratings: NEMA 12
4. Location: See Section 34 20 20 – Traction Rectifier, for further requirements

2.02 OPERATIONAL REQUIREMENTS

A. The operation of the NGD shall be in accordance with the following logic, built into
the microprocessor-based controller. Parameter settings, such as time delays and
voltage and current threshold levels shall be adjustable through the operator interface
panel. Determine the default values of the different NGD settings expounded herein,
and they shall be coordinated with and approved by the City before implementation.

1. If the negative bus to ground voltage of either polarity exceeds the preset safe
   value, the NGD shall close the appropriate thyristor and ground the negative bus.
   To avoid nuisance operation due to voltage transients, the NGD shall operate after
   a time delay T1 following the initial detection of over-voltage, and providing the
   over-voltage condition is still present. The T1 time delay shall be adjustable in
   the 100-600 ms range, and the safe voltage set point shall be adjustable in the
   50-100 V range, in steps of 5 V.

2. With the negative bus grounded through the NGD, the NGD shall monitor the
   magnitude and duration of the current flowing through it. If the current does not
   exceed a preset threshold, then no further action shall be taken, except for raising
   local and remote alarm that the NGD is closed. If the high rail potential triggering
   the NGD has been caused by the trains’ operation along the Honolulu High-
Capacity Transit Corridor Project (HHCTCP) system, the NGD will open naturally when the local rail potential reverses polarity (which will interrupt the current through the closed thyristor).

3. If the current through the NGD is higher than a preset threshold current (adjustable) and the high current condition persists for duration longer than a time delay T2 (also adjustable), this shall be interpreted by the NGD as a positive-to-ground fault somewhere in the HHCTCP TES system. Accordingly, local and remote alarms shall be raised indicating a dc ground fault condition. Such alarms are intended to alert operators in the Operations Control Center (OCC), which in turn can attempt to isolate the ground fault by selectively de-energizing through remote control line sections near the affected TPSS. The threshold current shall be adjustable in the 5-50 A range, and the T2 time delay in the 15-150 sec range.

4. The NGD shall be designed to withstand the maximum currents (by magnitude and duration) that may occur in a worst-case ground fault, such as failure or short of a dc surge arrester inside the TPSS. The Core Systems DBOM Contractor may introduce high-level current threshold in the NGD controls, such as 1,000 A, that if exceeded should result in immediate shutdown of the rectifier (if this helps avoid the need to size the NGD for high short-term currents). The NGD grounding requirements shall comply with IEEE 80, 81, 141, 142, 837, C2, NFPA 70, 780, and UL 467 standards.

2.03 CONTROL EQUIPMENT

A. The logic for the sensing and control functions shall be implemented by using microchip technology, with appropriate interfaces for analog inputs and digital and discrete outputs. Programming shall be in non-volatile memory, which shall be re-programmable to alter function and configuration. All setup and application programming shall be provided by the Core Systems DBOM Contractor.

B. The operator interface panel shall allow the present voltage, current and time-delays settings to be reviewed on a Liquid Crystal Display (LCD) type display. The interface panel shall also have an update mode, which shall permit changing these settings within the built-in ranges by using fixed step increments. The NGD shall be also equipped with a re-settable operations counter. Access to the settings update mode and vital controls of the NGD shall be available only to authorized personnel. The limits are stored in the form of voltage-time characteristic curves.

C. Keypad-operated controls shall be provided (complemented with authorized access measures) to allow blocking the triggering of the thyristor during maintenance, and shall permit operator-initiated closing of the thyristor for testing purposes. The status indication system of the NGD shall appropriately reflect such modes (i.e. NGD blocked and NGD manually closed).

D. The NGD controller shall be provided with self-test functions, some of which shall be performed when the NGD is turned on, while others shall be carried out when the NGD is in normal operation. Failure of a self-test function shall trigger local and remote alarm of “NGD failure,” with local indication provided as to the nature of the detected problem.

E. The NGD shall be supplied from the 125 V dc control power system. Adequate protection shall be provided against voltage transients in the 125 V dc systems that could affect the operation of the NGD. The NGD shall be designed to pass the IEEE surge withstand capability (SWC) tests in accordance with ANSI C37.90.1, and
comply with ANSI 62 standard. Internal power supplies modules shall be constructed so that they can be easily replaced.

F. Local Alarm Indication Panel. An alarm panel, or alarm log accessed for review through the operator interface display, shall be provided on the front of the negative enclosure. The alarms panel/log shall provide information on present alarms in sufficient detail for troubleshooting purposes, and status indications of the NGD.

G. The NGD shall include the necessary controls, relays, circuitry and terminals to communicate its status. Three independent, spare, relay type outputs shall be provided, for possible future use.

H. At a minimum, the following indications shall be provided from the NGD and sent to the TPSS PLC/Annunciator panel for display on the LCD screen and the OCC. These alarms shall not be of the latch-in type and shall automatically reset to the normal status upon corresponding change in the NGD status. See the RFP Plans for further requirements.

1. NGD – On-Off status
2. NGD – High Running Rail Potential
3. NGD – High/Sustained Current
4. NGD – Trouble
5. NGD – Disconnect Switch Position

2.04 RELIABILITY
A. The design, manufacturing quality, workmanship, testing, component selection, and construction of the NGD shall be carried out to ensure high reliability commonly attributed to power substation equipment. See Section 34 20 01 – Traction Electrification - General Requirements, for further requirements.

2.05 CABLING AND TERMINAL CONNECTIONS
A. Size the NGD cables and terminal connections to satisfy continuous current rating of the NGD as described herein. Comply with ASTM B3, B8, B33, and UL 44 standards.
B. Refer to Section 34 20 50 – Miscellaneous Materials and Devices and Section 34 20 60 – Traction Power Cables, for further requirements

2.06 INITIAL PROVISIONING
A. Each complete Negative Ground Switch assembly shall be provided with an itemized list of parts with quantities, order preference, and price that the Contractor recommends for 2 years of operation before restocking. The reference number for each item shall include the Contractor’s and the original manufacturer’s part numbers. See Technical Provision TP-03, “O&M Performance Requirements” for further requirements.

2.07 SUPERVISORY CONTROL AND ANNUNCIATION REQUIREMENTS
A. Remote supervisory control and annunciation circuits shall be provided between each Negative Grounding device assembly and the substation PLC/Annunciator panel. See Section 34 20 35 – Control and Annunciation System, and the RFP Plans for further requirements.
PART 3 – EXECUTION

3.01 INSTALLATION
   A. See Section 34 20 20 – Traction Rectifier, for installation requirements within the negative bus cubicle.

3.02 TESTING
   A. Testing shall be provided in accordance with Section 34 20 80 – Traction Electrification System Testing.
   B. See Technical Provision TP-02, “Verification, Testing and Acceptance” for further requirements.

END OF SECTION
SECTION 34 20 35
CONTROL AND ANNUNCIATION SYSTEM

PART 1 – GENERAL

1.01 SUMMARY

A. Description:

1. The Work of this Section includes the requirements for the design, procurement, and installation of Control and Annunciati and Annunciation systems to provide for interface of the Traction Electrification System (TES) Facility Prefabricated Buildings Traction Power Substation (TPSS), Gap Breaker Station (GBS), interface to the Supervisory Control and Data Acquisition (SCADA) system equipment, and the Emergency Trip System (ETS) and Transfer Trip System (TTS) Fiber optic communication links.

2. The Core Systems Design-Build-Operate-Maintain (DBOM) Contractor’s Work includes but is not limited to the following:

a. Providing Master Programmable Logic Controllers (PLC) within each substation and GBS.

b. Providing PLC Input/Output (I/O) modules and ports, for control, communication, and networking devices to integrate the Multifunction Protective Relays (MFPR) supplied within the TES ac and dc Switchgear equipment.

c. Providing a local Liquid Crystal Display (LCD) screen for interface with the PLC for the control and annunciation of the TPSS and GBS equipment,

d. Interface components and software for connecting the PLC to the SCADA system.

e. Cabinets for housing the PLC, its components, and the local LCD screen

f. Coordination with interfacing the Communications Interface Cabinet (CIC) and the PLC/Annunciation Panel components to obtain a complete and operable system.

g. Product operating software and specific application logic programmed software required to control and annunciate the TPSS and GBS as described in the RFP Plans.

h. Interface components as necessary to provide for an independent communication transmission system utilizing an independent dedicated physical Optical Network. Utilize the Fiber Optic Cabling Network (FOCN) as described in Section 27 13 01 – Fiber Optic Cabling Network, for implementing the independent Optical Network for the Transfer Trip System (TTS) between TPSS and the GBS as indicated in the RFP Plans.

i. Interface components, as necessary, to provide for an independent communication transmission system utilizing an independent dedicated physical Optical Network. Utilize the FOCN as described in Section 27 13 01 – Fiber Optic Cabling Network, for implementing the independent Optical Network for the Emergency Trip System (ETS) between TPSS and the GBS as indicated in the RFP Plans.
B. Section Includes:
   1. PLC System Equipment
   2. Liquid Crystal Display (LCD) Operator Control Panel
   3. Communication Networks
   4. Software
   5. PLC/Annunciator Panel Construction
   6. Power Supplies
   7. Supervisory Control and Annunciation Requirements
   8. Manufacturers
   9. Initial Provisioning

C. Related Sections:
   1. Section 27 13 01 – Fiber Optic Cabling Network
   2. Section 27 20 01 – Communications Transmission System
   3. Section 27 30 01 – Telephone Systems
   4. Section 27 60 00 – SCADA System
   5. Section 27 90 06 – Network Timing System
   6. Section 34 20 01 – Traction Electrification - General Requirements
   7. Section 34 20 05 – Prefabricated Enclosures
   8. Section 34 20 10 – AC Switchgear
   9. Section 34 20 15 – Rectifier Transformer
   10. Section 34 20 20 – Traction Rectifier
   11. Section 34 20 25 – DC Switchgear
   12. Section 34 20 30 – Negative Grounding Device
   13. Section 34 20 40 – Emergency and Transfer Trip System
   14. Section 34 20 45 – DC Control Power System
   15. Section 34 20 50 – Miscellaneous Materials and Devices
   16. Section 34 20 55 – Wayside DC Disconnect Switches
   17. Section 34 20 80 – Traction Electrification System Testing

1.02 PRICE AND PAYMENT PROCEDURES

A. General: Separate measurement or payment will not be made for the Work required under this Section. All cost in connection with Work specified herein will be considered to be included with the related item of work in the General Conditions requirements, or incidental to the Work.
1.03 CODES, STANDARDS, AND RECOMMENDED PRACTICES

A. American National Standard Code (ASC):
   1. ASCII General

B. American National Standards Institute (ANSI):
   1. ANSI X3.15 Standard for Bit Sequencing of ASCII in Serial-By-Bit Data Transmission

C. Electronic Industries Association (EIA):
   1. RS-232C Physical Interface between Data Terminal Equipment and Data Communication Equipment
   2. RS-422 Electrical Characteristics of Balanced Voltage Digital Circuit
   3. RS-485 Standard for Data Communication Equipment

D. Institute of Electrical and Electronics Engineers (IEEE):
   1. IEEE 730 Software Quality Assurance Plans
   2. IEEE 802.1 Standard for Overall architecture of Local Area Network and Internetworking
   3. IEEE 802.8 Standards on Fiber-Optic LANS
   4. IEEE 1219 Software Maintenance Standard

E. Instrument Society of America (ISA)

F. National Electrical Manufacturers Association (NEMA):
   1. NEMA ICS6 Enclosures for Industrial Controls

1.04 PERFORMANCE REQUIREMENTS

A. Components of the Control and Annunciator system shall consist of a master logic controller PLC with associated I/O devices. The master PLC system, within the TPSS and GBS, shall be designed and programmed to integrate the required control functions to provide substation monitoring, control, and data logging.

B. Provide all components necessary to perform status, data allocation, communications, and logic functions as described herein.

C. Provide master PLC system of safety rated design to provide for increased reliability to the control system.

D. The PLC shall perform the following communications interfacing functions:
   1. Integral or external interface components to the FOCN to provide for the independent Optical Networks for the ETS and TTS, as indicated in the RFP Plans
   2. Communications between the PLC and the Communications Transmission System (CTS) shall be through an Ethernet Managed Switch or equivalent communications device to assure Quality of Service bandwidth guarantees on the data ingress side of the SCADA network.
   3. Interface to the CTS and SCADA subsystem by these PLCs shall be by using standard IEEE 802.3 Ethernet 10Base-T, or IEEE 802.3u 100Base-T Fast Ethernet data protocols, or 100Base-FX Optical Ethernet data protocols.
4. As described in Section 27 60 00 – SCADA System, communication at this interface (PLC to Ethernet Switch) shall be by means of Category 6 copper cabling or a fiber optic interface. Physical termination of the Category 6 copper cabling shall be at the CIC provided by the SCADA system. It is the responsibility of the Core Systems DBOM Contractor to coordinate between PLC and SCADA components suppliers to provide an interface with a minimum of protocol conversion devices.

5. PLCs shall be responsible to convert any vendor-provided SCADA I/O-side protocols into Ethernet protocols designated above for transmission by the Ethernet Managed Edge Switch equipment provided by CTS.

6. Communication link with the LCD Panel through an independent port or network with the PLC.

7. Refer to Section 27 20 01 – Communication Transmission System and Section 27 60 00 – SCADA System, for interfacing the PLC, the CIC cabinet and the Ethernet Edge switch.

E. The PLC shall perform the following status, data allocation, and logic function:

1. The PLC shall perform local and remote control of the substation operation. Logic shall be provided to allow the local control of the ac Switchgear and dc Switchgear equipment to perform the opening and closing of circuit breakers and reporting of alarms.

2. The PLC shall have a failsafe mode whereby if loss of communication with the SCADA system occurs, the PLC shall be capable of an independent, automatic mode of safe operation with the continuation of all functions of the PLC system within the substation, performing local logical control and operation of the TPSS and GBS functions, without the need for any OCC intervention.

3. The means to override the automatic SCADA operation, by manual means, shall be provided at the local PLC to be used by authorized technicians in troubleshooting and maintenance of the system.

4. The PLC shall perform sending supervisory polling signals to any of its local I/O devices and provide a SCADA alarm in the event of circuit discontinuity. The PLC shall convert any supervision polling alarm or status notifications to one of the Ethernet data transmission formats required for interface to the SCADA system.

5. The local area networks (LANs) between the PLC system and the MFPR LAN, providing communication with each ac and dc Switchgear by industry standard protocols. The MFPR relays are to be considered as I/O type device. The master PLC shall provide logical control, alarm and indication, and all interface requirements through network control of these relays and subsequent control of the TES equipment. Proper choice of communication protocol and network speed of the PLC for the transmission of the data between the TPSS, GBS, and the SCADA system components shall allow for seamless transmission without the need of installing specialized protocol conversion devices. See Section 34 20 01 – Traction Electrification - General Requirements, for further requirements.
6. PLC shall perform control operations from remote commands as initiated by the Operations Control Center (OCC). These commands are as indicated in the RFP Plans but are not limited to the following:
   a. Open/Trip and Close of the ac circuit breaker  
   b. Open/Trip and Close of the main dc circuit breaker  
   c. Open/Trip and Close of all dc feeder breakers  

7. The PLC and its components shall be installed within the PLC/Annunciator panel. The panel shall serve as an interface point of the PLC to the CIC, for the SCADA system, connection to the Fiber Distribution Panel (FDP) within the CIC, and other hard wired controls if required for the Prefabricated Enclosure subsystems, specified in Section 34 20 05 – Prefabricated Enclosures.  

8. Provide coordination and automatic synchronizing of all time and date stamps between the PLC, LCD Display panel, the MFPR network, and the SCADA system. Events occurring on the MFPR shall have the same time and date stamp of the SCADA system records. Provide cabling interface to the time synchronization devices within the CIC. Refer to Section 27 90 06 – Network Timing System, for details of the Network Timing Synchronization Subsystem.  

9. Provide levels of password protection for the PLC system. Protection shall allow only authorized personnel from changing parameters, setup logic. The number of levels shall be as approved by the City.  

10. Provide logic to perform tripping of the Device No. 186 and 286 as required within the TPSS and GBS. The PLC logic required is as described in the TES Division 34 Technical Provisions and includes logic to prevent closing of the rectifier transformer, ac circuit breaker and rectifier cathode dc circuit breaker when any of the rectifier enclosure doors are open. See the RFP Plans for further requirements.  

11. If the Contractor chooses to implement the Lockout 186 feature under software logic through the TPSS and GBS PLC systems, a manual reset button shall be required at the PLC/Annunciator panel for this function.  

12. When a lockout 86 function is initiated by an ETS trip device, manual resetting of the activated trip device is required before the 86 function can be manually reset and the subsequent manual restoration of power to the affected Contact Rail sections through the manual reclosing of the dc feeder breakers.  

13. The PLC shall provide control, indication, status, alarm and data information to the SCADA system in the form of Discrete (Binary) and Continuous (Quantitative) messages as indicated in the RFP Plans, and Section 27 60 00 – SCADA System, for further requirements.  

14. Provide within the PLC a stored log file with date and time stamp for at least 1000 events, to be displayed on the LCD screen. The events shall include but not be limited to the following:
   a. Failed action logic events for any device or equipment, such as the ETS pushbutton, ac and dc circuit breakers, etc, that have been initiated for action but fails to complete its programmed sequence within a prescribed adjustable time period, with table indicating incomplete sequence, breaker number, time, date, etc.
F. The Local LCD Screen shall perform the following functions:

1. Provide the user with facilities to monitor and intervene in the operation of the substation in a direct manner for local control of substation equipment during maintenance operations. The settings placed by local service personnel at the LCD cannot be changed or overridden by the OCC during the field maintenance operations. At the TPSS and GBS, the LCD screen provisions shall be made for maintenance personnel to be able to return control to the OCC via Remote/Local settings with visual indication that the remote status of the system has been restored before the maintenance technician leaves the premises. See Article 1.04.H herein, for further requirements of Local/Remote selector switch.

2. Provide for graphical indication on demand of the Single Line Diagram indicating device status of the equipment within the TPSS or GBS including the ac and dc circuit breakers, rectifier and rectifier transformer status, and identify the contact rail being fed.

3. Provide display status and annunciation and logging of substation equipment alarms, monitoring of the PLC health, and its I/O devices.

4. Provide for programming and setup of the PLC and local network.

5. Perform Annunciator display screen operations in accordance with these Specifications.

6. The LCD operator panel shall be mounted on the front face of the PLC/Annunciator panel.

7. The LCD shall display total power consumption and electrical demand.

8. LCD shall display the live HECO primary incoming voltage integrated with the single line diagram display in phase to phase and phase to neutral on demand by maintenance personnel.

9. In general, the LCD screen shall indicate alarms and provide for control and reset functions similar to those to be provided at the OCC. See the RFP Plans for further requirements of the LCD screens.

G. Emergency and TTS interfaces to the PLC shall be as follows.

1. Emergency Trip System:
   a. Initiation functions shall be accomplished between substation dc feeder circuit breakers, implemented through interface and logical control with the PLC and MFPR.
   b. For the ETS provide independent PLC to PLC Fiber Optic Physical Communication networks with supervised failure of signal continuity and its network status alarmed on trouble. The dedicated Fiber Optic components may be integral with the PLC equipment or utilize a copper to fiber optic modems (CFT). The fiber optic communication Network as specified in Section 27 13 01 – Fiber Optic Cabling Network, shall serve as the optical path for this PLC to PLC link.
   c. ETS pushbuttons at Passenger Stations, when activated, shall be hard wired, interfaced, and integrated with the PLC at the passenger stations as described in Section 27 60 00 – SCADA System. An independent fiber optic link from the passenger station PLC to the PLC at the mainline TPSS to trip dc breakers shall be provided as indicated in the RFP Plans, the Design Criteria...
Chapter 13, and as described in Section 34 20 40 – Emergency and Transfer Trip System.

d. For Passenger Station ETS pushbuttons, the reset logic shall reside in the passenger Stations PLC system and transmit the appropriate reset signal to the TPSS and GBS PLC system. See Section 34 20 40 – Emergency and Transfer Trip System, for further requirements.

e. Maintenance and Storage Facility (MSF) Yard Blue Light Station (BLS)/ETS pushbuttons, when activated, shall be hard wired copper interfaced and integrated with the PLC and its supervisory logic at the MSF OCC equipment communication equipment room, as indicated in the RFP Plans for monitoring the ETS switch and cabling as described herein. The ETS Trip signals shall be hard wired to the PLC and then transmitted through the independent fiber optic link to the PLC at the Yard TPSS to trip dc breakers, as indicated in the RFP Plans, the Design Criteria Chapter 13 Traction Electrification, and as described in Section 34 20 40 – Emergency and Transfer Trip System.

f. The hard wired ETS pushbutton switches shall be of a supervisory type by monitoring the continuity of the switch and the integrity of the wiring to determine that no electrical breaks have occurred, preventing the system from responding to an emergency push button trip activation. Lack of continuity of the circuit shall cause a trouble signal to be sent to the PLC and to the SCADA Communication Network to raise the alarm at the Yard Tower Control Center and OCC.

g. A separate ETS button shall be located at the Yard Control Tower for emergency trip functions, as indicated in the RFP Plans.

h. When the ETS push button switch has been unlocked and returned to its normal position, indication signals shall be transmitted by the PLCs to the Yard TPSS, to allow return of normal operations of the Yard TPSS. The reset lockout logic program shall reside within the Yard TPSS PLC to prevent the contact rail from being reenergized before the ETS pushbutton has been reset.

i. The PLC located at the TPSS and GBS shall monitor the continuity and electrical integrity of its ETS circuitry and shall provide trouble and activation alarms.

j. Activation of the ETS at the substation shall trip the substation, as indicated in the RFP Plans, and provide indication to the SCADA system as to the location of which ETS activation message was sent.

k. The event time and date shall be logged and archived at both the SCADA and at the TPSS PLC.

2. Transfer Trip System:

a. Initiation functions between substation dc feeder circuit breakers shall be implemented through interface and logical control with the PLC and Multifunction Relays.

b. An independent PLC to PLC Fiber Optic Physical Communication network for Transfer Trip operations shall be provided with supervised failure of signal continuity and its network status alarmed on trouble. The PLC shall be provided with Independent Fiber Optic Communication devices between substations for accomplishing the Transfer Trip Functions. These components may be as integral with the PLC equipment or copper to fiber
optic transceiver modems (CFT). The Fiber Optic Communication Network, as specified in Section 27 13 01 – Fiber Optic Cabling Network, shall serve as the optical path for this PLC to PLC link.

c. The PLC shall provide for the TTS status messages to the SCADA system reporting the time, date, and location on activation of the tripped breakers.

d. The event time and date shall be logged and archived at the TPSS PLC.

e. See the RFP Plans for further requirements of the control, alarm, and indication status requirements.

H. The TPSS and GBS shall be provided with a Local/Remote selector switch (LRSS) initiating the Local/Remote function through the master PLC. This switch allows local control of the TES equipment, with all device controls initiated through the master PLC. Under normal operating conditions, the TES equipment is set for Remote operation. The position of the LRSS shall be displayed on the LCD operator panel and separate local indicating lights on the selector switch enclosure.

1.05 SUBMITTALS

A. General: Refer to General Conditions for Submittal Procedures, and for Shop Drawings, Product Data, and Samples requirements and procedures.

B. Submit the following in accordance with Section 34 20 01 – Traction Electrification - General Requirements:

1. Manufacturer’s product description, catalog data and information, specific only to this system

2. Manufacturer’s arrangement, wiring, and detail drawings

3. Technical data and characteristics

4. Operation and maintenance manual

5. Description of equipment

6. Equipment drawings

7. Arrangement drawings

8. Details of interconnection

9. Wiring diagrams

10. Schematic diagrams

11. Elevation drawings

12. Enclosure details

13. Production test report

14. Operating instructions

15. Installation instructions

16. Testing instructions

17. Maintenance instructions

18. Bill of materials

19. Spare parts list
20. Application Software
21. Product Software and licenses
23. Training Manuals and Equipment: Training manuals and equipment shall conform to the requirements of the Management Provisions

C. Submit data indicating that the PLC and Copper to Fiber (CFT) have adequate optical power levels for transmission for fiber optic signals. See Sections 27 13 01 – Fiber Optic Cabling Network and 27 20 01 – Communications Transmission System, for optical budget calculation.

1.06 QUALITY ASSURANCE
A. General: Refer to General Conditions requirements for quality assurance requirements and procedures.
B. Comply with all applicable Federal, State, and Local Laws, Regulations, and Codes including those referenced in Article 1.03.

1.07 DELIVERY, STORAGE, AND HANDLING
A. As the Control and Annunciation equipment is installed within the Prefabricated Enclosure, the Core Systems DBOM Contractor shall coordinate the delivery, storage, and handling of the Control and Annunciation equipment with the requirements as described in Section 34 20 05 – Prefabricated Enclosures.

1.08 WARRANTY
A. The Core Systems DBOM Contractor suppliers shall warrant that their products are free from defects. Warranty shall conform to the requirements of the General Conditions requirements.

PART 2 – PRODUCTS

2.01 PLC SYSTEM EQUIPMENT
A. Electronic I/O modules: The I/O electronic intelligent modules provide remote I/O capability for the master PLC and shall provide:
   1. High-speed communication.
   2. Central and distributed fault diagnostics.
   3. Direct two-wire connection of sensors
   4. The I/O shall be modular, to allow the changing of I/O without disturbing field wiring.
   5. The I/O modules for Digital input modules, Digital output modules shall be through twisted pair cable (shielded) electrical connection.
   6. Provide counters, comparator, and bidirectional ASCII communication function modules.
7. Diagnostics error and fault alarms shall be provided for I/O modules and communication lines. They shall include fault transmission, internal bus faults, overloads and short circuits.

8. The I/O Input/Output remote modules shall be dustproof and designed to withstand the environmental requirements as indicated in the RFP Plans and in Section 34 20 05 – Prefabricated Enclosures. Each module shall include suitable signal and safety grounds.

B. Master PLC:

1. The master PLC shall organize data traffic autonomously via the shielded wire bus cable to the remote I/O units and the MFPR network. The master PLC shall coordinate and control all communication within the TPSS and GBS and shall interface with the operator’s panel for data acquisition and logging. Connections to the SCADA shall be accomplished via the master PLC. See Section 34 20 25 – DC Switchgear, Section 34 20 10 – AC Switchgear, Section 34 20 15 – Rectifier Transformer, and as indicated on the RFP Plans.

2. The PLC shall be provided with the central processing unit, and I/O modules plugged into bus units.

3. The PLC shall be provided with preprogrammed functions including but not limited to Boolean logic, latching/unlatching, counters, timers, arithmetic, AND/OR logic, basic arithmetic operations, comparison operations, code conversion, shift operations, incrementing, and decrementing.

4. Programming languages shall include Statement List, Control System Flowchart, and Ladder Diagramming.

5. Ports to interface with the network requirements, Laptop Computers, Modems, LCD, and Printers.

6. The PLC will also be provided with a universal serial bus (USB) port to transfer information to a USB stick for permanent storage.

2.02 LIQUID CRYSTAL DISPLAY (LCD) OPERATOR CONTROL PANEL

A. The LCD shall be a flat screen display device with the following features:

1. The operator panel shall be capable of Data Storage, Diagnostics, Operator Control, and Systems Monitoring Functions. Cyclic transmission of the date and time of day to the programmable controller shall be provided.

2. The operator panel shall meet the following minimum technical characteristics:
   a. Display: 17 inch minimum LCD, adjustable viewing angle
   b. LCD screen provisions for all functions and operations
   c. External Keyboard: Membrane keyboard with tactile-touch keys for backup operational features. Touch screens are acceptable subject to approval by the City.
   d. Reset, acknowledge and other pushbuttons to accomplish the tasks required.
   e. A local horn with adjustable volume.
   f. The LCD shall be a single unit. The LCD shall be solid state and have no moving parts. The microcomputer unit with integral screen shall be suitable for mounting on an enclosure door.
g. The LCD components shall be factory wired and assembled to facilitate installation.

h. Configure, program, and test the application software and interface.

i. The LCD Annunciator display shall contain all windows as defined during design development. Under alarm conditions, the offending window will flash and an audible alarm will be raised. When interrogated, the alarmed window shall reveal the specific nature of the alarm as described in these Specifications.

j. Provide all components necessary to perform status, data allocation, communications, and logic functions as described herein.

B. Annunciator Function: The Annunciator Functional Operations shall be provided with pushbuttons portion of the LCD to provide for TEST acknowledgment and RESET. The button shall be provided with an identifying nameplate of white-face black core laminoid.

1. The Local Display Operator Panel shall perform Annunciator display screen operations in accordance with the following:
   a. The Annunciator display shall contain all windows as approved by the City.
   b. Under alarm conditions, the offending window will flash and an audible alarm will be raised.
   c. When interrogated, the alarmed window shall reveal the specific nature of the alarm.
   d. The screen flashes, whether in local or supervisory control mode. The horn sounds in local only. Lock-in applies for momentary input.
   e. Depressing the acknowledge button stops the horn, and the indication status or alarm stays on steady. When the trouble condition is removed, the indication goes dark (only after reset).
   f. Annunciator shall have screens with various flashing and steady on suggested colors.
      1) Blue Steady – Normal State
      2) Yellow Flashing – Alarm condition
      3) Red Steady – “Trip” condition
      4) Blue Flashing – Alarm condition cleared

C. Screen:

1. Screens shall be provided for the following.
   a. Main Screen: This screen shall include the buttons to go to other screens, as well as to log in and out.
   b. Operation: This screen shall show the substation one line diagram of breakers/devices depicting all their current states.
   c. Signal: This screen shows the device and their current states.
   d. Breaker: This screen is a pop up that appears when the Breaker in the above two screens is pressed. This screen allows the operator to control the Breaker.
   e. Annunciator: This screen displays status data, either single points or grouped by function, used to alert a maintenance personnel of an existing alarm condition.
f. Tabular: This display lists all current points in the alarm state, for all points defined as alarms.
g. Events: This screen, accessible from the Tabular display, shows all current events, for all points defined as events.
h. Analog: This screen shows any and all analog meter values that are found on the Operation's screen one line diagram.
i. Drill Down Screen: These screens to see further alarms and data as required.

2. Provide individual buttons at screen bottom for being able to select each screen type as listed in Article 2.02C herein.

3. The LCD will be time synchronized via the Ethernet protocol link. The HMI will be capable of receiving the month (1-12), date (1-31), hour (0-23), min (0-59) and second (0-59) in byte form to synchronize. Provide each screen with the following:
   a. Date: mm/dd/yyyy format
   b. Time: Military format, hh:mm:ss

4. The following buttons suggested at the bottom of the screen:
   a. Main Menu
   b. Alarm
   c. Operation
   d. Previous Screen
   e. Analog
   f. Signal
   g. Breaker
   h. Events

2.03 COMMUNICATION NETWORKS

A. Substation Local Communication Network: Communication networks shall provide a bus-type Local Area Network (LAN configuration to control the information flow between the PLC, the LCD operator panel, and the MFPR. The connection shall be by copper type connection. Fiber optic is also allowable.

B. Substation to SCADA Communication Network Devices: The master PLC system shall communicate with the SCADA via Ethernet utilizing Category 6 copper cable or Fiber Optic cables.

C. Substation to Substation for the TTS:
   1. The TTS shall communicate via an independent dedicated physical Optical Network components through the CIC/FDP installed within TPSS and GBS, directly to the PLC, or through external copper to fiber optic transceivers modems (CFT), as indicated in the RFP Plans.
   2. The copper fiber optic transceivers modems (CFT) shall transmit multiple signals, as required, from the PLC for retransmission through the fiber to companion CFT's in other traction power facilities via single-mode fiber optic links.
   3. Power supply shall be from the facility’s 24 V dc or 125 V dc systems.
   4. Provide all equipment mounting hardware and accessories, as required.
5. Further requirements for Transfer trip function between adjacent substations shall be provided as described in Section 34 20 40 – Emergency and Transfer Trip System.

D. MSF Yard BLS/ETS to Substation for the ETS:
1. The BLS/ETS within the MSF Yard, are connected to PLC at OCC Equipment Room through copper cable connections as indicated in the RFP Plans. Communication via an independent dedicated physical Optical Network to Yard TPSS PLC as indicated in the RFP Plans is also to be provided. Components located within the TPSS and GBS PLC/Annunciator panel shall be provided with components as necessary to interface the PLC through external copper to fiber optic transceivers modems (CFT) as indicated in the RFP Plans.

2. The copper fiber optic transceivers modems (CFT) shall transmit multiple signals as required from the PLC for retransmission through the fiber to companion CFTs in other traction power facilities via single-mode fiber optic links.

3. Power supply shall be from the facility’s 24 V dc or 125 V dc systems.

4. Provide all equipment mounting hardware and accessories, as required.

5. Further requirements for Emergency trip function between adjacent substations shall be provided as described in Section 34 20 40 – Emergency and Transfer Trip System.

E. Optical communications networks shall be capable of operating with optical cable having the characteristics as described in Section 27 13 01 – Fiber Optic Cabling Network and Section 27 20 01 – Communications Transmission System.

2.04 SOFTWARE
A. Software Standardization: The PLC system software provided by the Contractor, and third-party commercial off-the-shelf software suppliers participating in this project, shall comply with consistent, industry-accepted software standards in order to facilitate PLC system maintenance and enhancement.

1. Software shall comply with industry standards produced by standard organizations, such as ANSI, ISO, IEC, IEEE, OSF, and X/Open including, IEEE 730 Software Quality Assurance Plans, and IEEE 1219 Software Maintenance Standard.

2. Software upgrades and support shall be a required part of this Contract. Software upgrades shall be accomplished in such a way as to allow the system to recover to an earlier installed version in the event of any failure in the upgrade process.

B. Provide preprogrammed PLC functional and application software to configure, program, and test the PLC and the software for operating the LCD operator panel and any software that integrates the PLC and the TES equipment MFPR.

C. All software programs and project specific codes shall become property of the City. Ownership and possession of all licenses, software files, documentation, access codes, keys, copyrights, and other pertinent material shall be conveyed to the City upon completion of the project as part of deliverables.

D. Software documentation shall be provided in sufficient detail to permit the City to modify the system configuration without the assistance of the Contractor. At the time of delivery, Windows compatible Digital Versatile Disc, (DVD-R) media shall be
provided, which contains all the source code, drivers, executable and configuration files, and software development tools necessary to recreate and maintain the system. Should the system require software revision by the Contractor, separate DVD-R media that contain the changed executable files and documented modified source code shall be furnished by the Contractor.

E. Provide a developer’s license of all software furnished to the City.

F. Provide all required programming cables between the PLC and laptop computers as indicated in Section 34 20 01 – Traction Electrification - General Requirements, and the Operations and Maintenance Technical Provisions.

2.05 PLC/ANNUNCIATOR PANEL CONSTRUCTION

A. Equipment subcomponents shall be Manufacturer’s Standard Product with proven record of operation for its intended purpose.

B. Equipment shall be suitable for operation in the TPSS and GBS enclosure environment and seismic zone defined herein.

C. The master PLC/Annunciator panel enclosures shall be furnished inside and out with standard color used in each equipment location.

D. The master PLC/Annunciator panel enclosure shall include suitable signal and safety ground networks. The safety ground shall be isolated from the signal ground and shall be connected to the ground wire of the ac panel input. The signal ground shall be terminated on a separate stud connection.

2.06 POWER SUPPLIES

A. The 24 V dc and 125 V dc power supply as specified in Section 34 20 45 – DC Control Power System, shall provide power to the PLC/Annunciator Panel. Circuits shall be provided and fused such that the failure of one circuit shall not cause the full system to shutdown

2.07 INTERFACE WIRING FOR CONTROL FUNCTIONS

A. Provide wiring for Control, Alarms, and Status Indicator functions from the substation switchgear, dc Control Power System, Ventilation equipment, Fire Alarm functions, and the intrusion system to be terminated on terminal blocks in the PLC/Annunciator panel and wired to the PLC I/O dry contacts.

1. Verify that the PLC I/O contacts have adequate current and voltage ratings considering the ac and dc switchgear control circuits they are wired into.

2. If the contact ratings are inadequate, provide interposing relays with appropriately rated output contacts. Coordinate with the TES equipment supplier for their location and installation.

B. An intrusion alarm for the TPSS and GBS shall be provided. See Section 34 20 05 – Prefabricated Enclosures, Section 34 20 01 – Traction Electrification - General Requirements, and the RFP Plans for further requirements.

C. Provide 125 V dc Station Battery and Battery Charger shutdown, upon prefabricated enclosure damper flow switch loss of flow. Provided through the PLC logic or external logic relays. See Section 34 20 05 – Prefabricated Enclosures, and Section 34 20 45 – DC Control Power System, for further requirements.
2.08 SUPERVISORY CONTROL AND ANNUNCIATION REQUIREMENTS
   A. The local and remote control, indication status, alarm and analog functions for interface with the PLC/Annunciator, the LCD screen and the SCADA system and shall be as indicated in the RFP Plans and shall include the following:
      1. Open/Trip and Close of the ac circuit breaker
      2. Open/Trip and Close of the main dc circuit breaker
      3. Open/Trip and Close of all dc feeder breakers
      4. Open and Closed status and connected
      5. Test and disconnected position indications for all ac medium voltage and dc circuit breakers
   B. See Sections 34 20 20 – Traction Rectifier, 34 20 30 – Negative Grounding Devices, 34 20 50 – Miscellaneous Materials and Devices, and 34 20 55 – Wayside Disconnect Switches, for further requirements of control, status, and alarms.

2.09 MANUFACTURERS
   A. Acceptable list of manufacturers of safety rated PLC suppliers are Allen Bradley, Siemens, or approved equal.

2.10 INITIAL PROVISIONING
   A. Each complete component and assembly shall be provided with an itemized list of parts with quantities, order preference, and price that the Contractor recommends for 2 years of operation before restocking. The reference number for each item shall include the Contractor’s and the original manufacturer’s part numbers. See Technical Provision TP-03, “O&M Performance Requirements” for further requirements.

PART 3 – EXECUTION

3.01 INSTALLATION
   A. Install the PLC/Annunciation equipment, Fiber Optic CFTs, LRSS, and control equipment within each TPSS and GBS prefabricated enclosure secure, plumb and level and in true alignment with related adjoining work.

3.02 TESTING
   A. See Section 34 20 80 – Traction Electrification System Testing, for further requirements.
   B. See Technical Provision TP-02, “Verification, Testing, and Acceptance” for further requirements.

END OF SECTION
PART 1 – GENERAL

1.01 SUMMARY

A. Description: The Work specified in this Section includes for coordinating the final design, procurement, installation, and testing of the components of the Emergency Trip System (ETS) and Transfer Trip System (TTS). The Work includes, but is not limited to, providing completed operational and functional ETS and TTS integrated with the Supervisory Control and Data Acquisition (SCADA) System, the Communication Transmission Systems (CTS) Fiber Optic Cabling Network (FOCN), the Blue Light Station/Emergency Trip Pushbuttons (BLS/ETS) at the passenger stations, the Maintenance and Storage Facility (MSF) Yard, and those at the Traction Electrification System (TES) facilities. The Work also includes for coordinating with the interface of the Programmable Logic Controllers (PLC) at the passenger stations, MSF Yard communication rooms, and the TES facilities’ equipment within the prefabricated enclosures.

B. Section Includes:

1. Emergency Trip System Components
2. Transfer trip System Components

C. Related Sections:

1. Section 27 13 01 – Fiber Optic Cabling Network
2. Section 27 20 01 – Communication Transmission System
3. Section 27 30 01 – Telephone Systems
4. Section 27 60 00 – SCADA System
5. Section 34 20 01 – Traction Electrification - General Requirements
6. Section 34 20 25 – DC Switchgear
7. Section 34 20 35 – Control and Annunciation System
8. Section 34 20 45 – DC Control Power System
9. Section 34 20 80 – Traction Electrification System Testing

1.02 PRICE AND PAYMENT PROCEDURES

A. General: Separate measurement or payment will not be made for the Work required under this Section. All cost in connection with Work specified herein will be considered to be included with the related item of work in the General Conditions requirements, or incidental to the Work.
1.03 CODES, STANDARDS, AND RECOMMENDED PRACTICES

A. National Fire Protection Agency (NFPA):
   1. NFPA 70 National Electric Code
   2. NFPA 130 Standard for Fixed Guideway Transit and Passenger Rail Systems

B. Hawaii Statutes and Code of Regulations

1.04 PERFORMANCE REQUIREMENTS

A. BLS/ETS System:
   1. Each BLS location shall contain an Emergency Trip Switch (ETS), and an Emergency Telephone (E-TEL) with a blue light as indicated in the RFP Plans and in Section 27 30 01 – Telephone Systems.
   2. As described in the Design Criteria Chapter 23 – Fire Life Safety, and as indicated in the RFP Plans, BLS/ETS shall be located at the TPSS, GBS, passenger station platforms, and within the MSF Yard and as required per NFPA 130 standard.
   3. The BLS shall allow personnel to communicate with the Operation Control Center (OCC) via the E-TEL. The BLS/ETS shall also provide, as described in Section 27 60 00 – SCADA System and Section 27 20 01 – Communication Transmission System, for the routing and identification of the originating call from the E-TEL to the OCC.
   4. The BLS/ETS at each mainline traction power facility shall be located on the outside wall in proximity to the entrance door of each TPSS and GBS. These BLS/ETS enclosures shall be electrically interconnected to the PLC located within the PLC/annunciation panel. Coordinate with the TPSS and GBS supplier to ensure that provisions have been made for mounting BLS/ETS units on the outside walls of the prefabricated enclosure. Electrical power shall be provided from the 125-V dc power panel for the BLS/ETS at the mainline TPSS. Ensure that these BLS/ETS enclosures are functionally and electrically integrated into the PLC, as specified in Section 34 20 35 – Control and Annunciation System. The ETS located at a TPSS and GBS shall be required to only trip its own dc feeder breakers, Main dc breaker and Main ac breaker as indicated in the RFP Plans.
   5. As indicated in the RFP Plans, the PLC at the passenger stations, the MSF Yard OCC communications equipment room, and each TPSS and GBS shall utilize a supervisory circuit to monitor the integrity of the ETS pushbutton switch circuit. If circuit trouble occurs, the alarm shall be logged by the SCADA System.
   6. Generally, the manually initiated ETS pushbutton switch initiates the trip signal to shutdown power to the Contact Rail sections through the PLC and the appropriate Multifunction Protective Relay (MFPR) located within the dc feeder breaker cubicles. The RFP Plans define the ETS tripping software logic schemes to be implemented within the TPSS and GBS PLC for performing these dc breaker trip tasks. The software logic program shall be provided with identification of each BLS/ETS device by the specific number as defined in the RFP Plans.
7. The PLC in the passenger stations provide a signal path for the initiation of the ETS pushbutton signal only and shall not contain PLC tripping scheme logic.

8. As indicated in the RFP Plans, when the Yard TPSS is out of service, mainline TPSS and the GBS shall serve as the power source to the MSF Yard. Provide for the ETS functions within the MSF Yard to shutdown the TPSS and GBS dc feeder to the MSF Yard for this condition only. An ETS pushbutton switch shall also be installed within the MSF Yard Tower Control Room, as indicated in the RFP Plans.

9. The SCADA System shall have the ability to perform Emergency Trip functions to shut off power to Contact Rail sections by tripping the dc Breakers through the workstation consoles at the OCC, as described in Section 27 60 00 – SCADA System, Section 27 90 00 – Operations Control Center Ancillary Equipment, and as indicated in the RFP Plans.

10. As indicated in the RFP Plans, initiation of ETS pushbutton switches shall be logged to the TPSS and GBS PLC for transmission to the SCADA System. A TPSS emergency shutdown by the local TES facility ETS shall be displayed on the local liquid crystal display (LCD) screen. In the event of equipment failure or circuit continuity problems of the TES facility ETS, alarms shall be displayed on the TPSS and GBS LCD screen panel identifying the location and nature of the ETS problem and also sent to the SCADA System.

11. The time from initiation of ETS initiation to delivery of trip control signal to the traction power equipment and annunciation at the OCC shall be less than 2 seconds. See Section 34 20 35 – Control and Annunciation System, and Section 27 60 00 – SCADA System, for further requirements.

12. For purposes of sending the breaker trip activation signal to the TPSS/GBS, the single mode drop cable running between TPSS/GBS shall be utilized for the primary transmission of messages. Fiber strands shall constitute a direct point-to-point connection between TPSS/GBS and shall not be part of the shared switched fiber optic transmission system.

13. The TPSS and GBS PLC/Annunciator panel shall house the Copper to Fiber Transceiver (CFT) interface modules and other communication interface components for the interconnection of the ETS. As indicated in the RFP Plans, the Communication Interface Cabinets (CIC) contains the fiber optic distribution panel (FDP) for the interface of fiber optic links of the FOCN between substations.

14. The TPSS and GBS PLC/Annunciator panel shall house the CFT interface modules and other communication interface components for the interconnection of the ETS. As indicated in the RFP Plans, the CIC contains the fiber optic distribution panel (FDP) for the interface of fiber optic links of the FOCN between substations.

15. In the event of CFT failure, provide a trouble alarm at the LCD screen and the SCADA system.

B. TTS:

1. The TTS shall initiate opening of dc feeder breakers at the TPSS and GBS facilities upon short-circuit fault detection by any one of the circuit breakers MFPR connected to the same contact rail electrical section.
2. DC feeder breaker tripping shall be initiated by either instantaneous over current, definite-time over-current, or current rate-of-rise protective functions. The dc feeder breaker MFPR detecting the fault shall be blocked from initiating the auto-reclosing mode as described in Section 34 20 25 – DC Switchgear.

3. The transfer trip signal between the TPSS and GBS facilities shall be transmitted via single-mode fiber optic cabling links. CFT located within each TPSS and GBS facility shall form the trip signal communication connection. The Transfer Trip Interconnect Network (TTIN) consists of a single 24-strand single-mode fiber optic cable connecting each Gap Break Station and Traction Power Substation in a “daisy-chain” multi-drop configuration. The transfer trip signal between the TPSS and GBS facilities shall be transmitted via these fiber optic cabling links, as indicated in the Contract Documents and the RFP Plans. See Section 34 20 35 – Control and Annunciation System, for further requirements.

4. Where contact rail sections are fed from multiple TPSS or GBS facility feeder breakers and when any of the TPSS or GBS facilities is taken out of service, circuitry and components for transfer trip operations shall be provided such that the out-of-service TPSS or GBS shall not inhibit transfer tripping operations of the remaining in-service TPSS and GBS facilities. The transfer tripping scheme shall be automatically extended to include TPSS or GBS that are added to extend a contact rail segment.

5. The PLC, as specified in Section 34 20 35 – Control and Annunciation System, shall provide for all transfer trip logic between TPSS and GBS facilities utilizing the fiber optic link as provided in Section 27 13 01 – Fiber Optic Cabling Network.

6. The TTS shall be self-monitoring, and its electronic equipment shall feature self-diagnostics. The integrity of all fiber optic communication and control circuit schemes between equipment and the PLC-to-PLC optical links shall be continuously monitored. In the event of equipment failure or circuit continuity problems, alarms shall be displayed on the LCD at the TPSS and GBS LCD screen panel and sent to the SCADA System identifying the location and nature of the problem.

7. The dc circuit breaker detecting the fault as well as the transfer-tripped circuit breakers connected to the same contact rail section in other traction power facilities shall be blocked from initiating the auto-reclosing mode.

8. Power supply to all equipment and devices inside the traction power facilities shall be from the 24 V and 125 V dc systems as specified in Section 34 20 45 – DC Control Power System.

9. The TPSS and GBS PLC/Annunciator panel shall house the CFT interface modules and other communication interface components for the interconnection of the TTS. As indicated in the RFP Plans, the CIC’s contain the FDP for the interface of fiber optic links between substations.

10. In the event of CFT failure, provide a trouble alarm at the LCD screen and the SCADA system.

11. The LCD screen shall indicate transfer trip alarms when a dc breaker has been successfully locked out due to a transfer trip initiation. Removal of the lockout at the 186 device as specified in Section 34 20 25 – DC Switchgear, shall reset the transfer trip circuit.
12. Transfer tripping of the dc feeder breakers within the MSF Yard TPSS is not required.

1.05 SUBMITTALS

A. General: Refer to General Conditions requirements for Submittal Procedures, and for Shop Drawings, Product Data, and Samples requirements and procedures.

B. Submit all data, design plans, procedures and samples in accordance with Section 34 20 01 – Traction Electrification - General Requirements, submittal requirements including, but not limited to the following:

1. A complete manual with drawings showing the interconnection of all components of the ETS. The manual shall integrate components of the ETS submitted under other Technical Provisions indicating manufacturer’s product specifications of BLS/ETS system, including operating description, mechanical parameters, contact configuration and ratings, and PLC’s general logic schemes for the ETS and TTS. The manual shall provide detailed description of the ETS and the TTS and reference all devices that are involved in tripping a contact rail section. The manual shall contain technical cut sheets and typical wiring schematics of the BLS cabinet, including construction details and the wiring interfacing to the PLC, MFPR, and the following:

a. BLS/ETS trip station panel construction, equipment schematic, wiring, and interconnection diagrams showing point-to-point wiring.

b. As indicated in Article 1.05.B1 herein, provide a similar manual for the TTS.

c. As multiple systems are part of these tripping systems, the manual shall provide description and signal path flow in a clearly written language for the system operators and system maintainers to follow the operation and signal path from beginning to completion of ETS and TTS operations.

d. Submittals for Test Plan, Test Procedures, and Test Reports shall be provided in accordance with Section 34 20 80 – Traction Electrification System Testing.


f. Training Manuals and Equipment: Training manuals and training equipment shall conform to the requirements of the Management Provisions.

1.06 QUALITY ASSURANCE

A. Refer to General Conditions requirements for quality assurance requirements and procedures.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As the Emergency Trip and Transfer Trip components are installed within the Prefabricated Enclosure, passenger stations and other locations within the Core Systems Design-Build-Operate-Maintain (DBOM) Contract and the MSF DB Contract, the Core Systems DBOM Contractor shall coordinate the delivery, storage, and handling of these components with the suppliers as indicated in the respective Technical Provisions requirements as described in Sections 34 20 05 – Prefabricated Enclosures, Section 27 13 01 – Fiber Optic Cabling Network, and Section 27 30 01 – Telephone Systems.
1.08 WARRANTY

A. The Core Systems DBOM Contractor suppliers shall warrant that their products are free from defects. Warranty shall conform to the requirements of the General Conditions requirements.

PART 2 – PRODUCTS

2.01 EMERGENCY TRIP SYSTEM COMPONENTS

A. Products for the ETS are provided under the Technical Provisions of this Core System DBOM Contract and shall be in accordance with those Technical Provision requirements. See Section 34 20 35 – Control and Annunciation System, Section 27 20 01 – Communications Transmission System, Section 27 30 01 – Telephone Systems, and Section 34 20 25 – DC Switchgear, for further requirements.

2.02 TRANSFER TRIP SYSTEM COMPONENTS

A. Products for the TTS are provided under various Technical Provisions of this Contract and shall be in accordance with those Technical Provision requirements. See Section 34 20 35 – Control and Annunciation System, Section 27 20 01 – Communications Transmission System, Section 27 30 01 – Telephone Systems, and Section 34 20 25 – DC Switchgear, for further requirements.

PART 3 – EXECUTION

3.01 GENERAL

A. The BLS/ETS system shall be compatible and integrated with the components of the FOCN, the Passenger Station PLC, and the Traction Electrification System facilities traction power equipment devices.

B. The TTS shall be compatible and be integrated with the components of the remote SCADA System PLC and with the traction power equipment devices provided at each of the substations.

3.02 INSTALLATION

A. BLS/ETS System:

1. Equipment provided for the BLS/ETS system shall be installed at passenger stations, TPSS, GBS, and MSF Yard locations in accordance with Section 27 20 01 – Communications Transmission System, Section 27 60 00 – SCADA System, Section 27 30 01 – Telephone Systems, and Section 34 20 35 – Control and Annunciation System.

2. Ensure the integration of all BLS/ETS equipment and overall BLS/ETS performance. Coordinate the terminations and connections of all BLS/ETS control cables in traction power facilities at passenger station and MSF Yard to PLC equipment system. Appropriate cable and wire designations and terminations shall be developed and implemented, complying with City requirements and NFPA 70 requirement.
3. Provide the inter-discipline and inter-contract coordination to ensure proper location of the BLS/ETS and power supply to the BLS/ETS equipment being provided from the 120 V ac essential power bus for passenger stations, the MSF Yard, and 125 V dc at the TPSS and GBS locations as indicated in the RFP Plans.

B. TTS:

1. Equipment provided for the TTS shall be, TPSS, GBS, and Section 27 60 00 – SCADA System, Section 27 30 01 – Telephone Systems, and Section 34 20 35 – Control and Annunciation System.

2. Ensure the integration of all TTS equipment and overall TTS performance. Supervise the terminations and connections of all TTS control cables in traction power facilities to the PLC equipment. Appropriate cable and wire designations and terminations shall be developed and implemented, complying with City requirements.

3. Install and terminate all fiber optic CFT modules of the TTS intrinsic to the traction power facility and inter-connecting equipment inside the traction power facility CIC cabinet.

4. Provide the inter-discipline and inter-contract coordination to ensure proper location of the TTS components.

3.03 TESTING

A. Factory and Field Testing shall be performed in accordance with the requirements of Section 34 20 80 – Traction Electrification System Testing.

B. See Technical Provision TP-02, “Verification, Testing, and Acceptance” for further requirements.

END OF SECTION
SECTION 34 20 45
DC CONTROL POWER SYSTEM

PART 1 – GENERAL

1.01 SUMMARY

A. Description: The Work of this Section includes for providing batteries, battery chargers, battery racks, dc distribution panelboards, and accessories to provide nominal 125 V dc control power for the substation equipment.

B. Section Includes:
   1. Operation
   2. Batteries
   3. Battery Chargers
   4. DC Distribution Panelboards
   5. DC to DC Converters
   6. Initial Provisioning
   7. Supervisory Control and Annunciation Requirements

C. Related Sections:
   1. Section 09 97 13 – Steel Coatings
   2. Section 26 05 00 – Common Work Results for Electrical
   3. Section 26 05 26 – Grounding and Bonding for Electrical Systems
   4. Section 26 05 33 – Raceway and Boxes for Electrical Systems
   5. Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems
   6. Section 26 08 10 – Testing of Electrical Systems
   7. Section 26 24 16 – Panelboards
   8. Section 26 33 53 – Static Uninterruptible Power Supply
   9. Section 34 20 01 – Traction Electrification - General Requirements
   10. Section 34 20 05 – Prefabricated Enclosures.
   11. Section 34 20 80 – Traction Electrification System Testing

1.02 PRICE AND PAYMENT PROCEDURES

A. General: Separate measurement or payment will not be made for the Work required under this Section. All cost in connection with Work specified herein will be considered to be included with the related item of work in the General Conditions requirements, or incidental to the Work.

1.03 CODES, STANDARDS, AND RECOMMENDED PRACTICES

A. ASTM International (ASTM):
   1. ASTM B187 Standard Specifications for Copper Stock
B. Institute of Electrical and Electronics Engineers (IEEE):
   1. IEEE 1106  Recommended Practice for Installation, Maintenance, Testing and Replacement of Vented Nickel-Cadmium Batteries for Stationary Applications
   2. IEEE 1115a  Recommended Practice for sizing Nickel-Cadmium Batteries for Stationary Applications

C. International Building Code (IBC)

D. National Electrical Manufacturers Association (NEMA):
   1. NEMA 250  Enclosure for Electrical Equipment (1,000 Volts Maximum), Type 1
   2. NEMA AB 1  Molded Case Circuit Breakers
   3. NEMA FU 1  Low-Voltage Cartridge Fuses
   4. NEMA PB 1  Panelboards
   5. NEMA PB 1.1  Instruction for Installation and Maintenance of Panelboards
   6. NEMA PE 5  Constant-Potential-Type Electric Utility (Semiconductor Static Converter) Battery Chargers

E. National Fire Protection Association (NFPA):
   1. NFPA 70  National Electrical Code (NEC)

F. Underwriters Laboratories (UL):
   1. UL 67  Panelboards

1.04 PERFORMANCE REQUIREMENTS

A. The battery system shall conform to the NEC and Occupational Safety and Health Administration requirements for batteries.

B. The battery shall be a standard, service-tested product of a manufacturer with proven Nickel Cadmium technology.

C. Battery capacities shall be adequate for the following load cycle over 8 hours from a fully charged state with the battery charger out of service:
   1. Normal continuous demand of substation for 8 hours at maximum ambient temperature with battery charger switched off. Over this 8-hour period, all ancillary loads including relays, indicating lamps, local Programmable Logic Controllers (PLC)/Annunciator Panel, Communication Interface Cabinet (CIC), Supervisory Control and Data Acquisition (SCADA) devices and supervisory control circuits are to be supplied by the battery.
   2. At the end of the 8-hour period, provide for the ability of two cycles of opening and closing the ac and dc circuit breakers.
   3. The calculation for determining the size of the battery shall include a minimum of 20 percent spare capacity.

D. The 125 V dc control power distribution panel shall be the point of connection between the batteries and the battery charger as indicated in the RFP Plans. The battery charger shall feed the dc power panel main breaker of the panel. A branch breaker shall be
provided for connecting the batteries. The panel bus shall be adequately sized and braced to perform this function. Independently removing battery charger or the batteries from service shall not affect the continued operation of the 125 V dc control power distribution system.

E. All battery equipment shall be designed, procured, and installed in accordance with IBC seismic requirements.

1.05 SUBMITTALS

A. General: Refer to General Conditions requirements for Submittal Procedures, and for Shop Drawings, Product Data, and Samples requirements and procedures.

B. Submit all data, design plans, procedures and samples in accordance with Section 34 20 01 – Traction Electrification - General Requirement, submittal requirements including, but not limited to the following:

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.
5. Training Manuals and Equipment: Training manuals and equipment shall conform to the requirements of the Management Provisions and technical provision TP-03, “O&M Performance Requirements”.

1.06 QUALITY ASSURANCE

A. General: Refer to General Conditions requirements for quality assurance requirements and procedures.

B. Comply with all applicable Federal, State, and Local Laws, Regulations, and Codes including those referenced in Article 1.03.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As the dc Control Power System is installed within the Prefabricated Enclosure, the Core Systems Design Build Operate Maintain (DBOM) Contractor shall coordinate the delivery, storage, and handling of the dc Control Power System with the requirements as described in Section 34 20 05 – Prefabricated Enclosures.

1.08 WARRANTY

A. Batteries shall have a warranty of 1 year from the date the battery is placed in service and an additional warranty of 19 years, pro rata, to deliver not less than 80 percent of its rated capacity.

B. The Core Systems DBOM Contractor suppliers shall warrant that their products are free from defects. Warranty shall conform to the requirements of the General Conditions requirements.
PART 2 – PRODUCTS

2.01 OPERATION

A. The battery and its associated charger shall be connected in parallel. The charger, in addition to charging the battery, shall carry the continuous connected load. The battery shall supply the remainder of the heavy short-time current demands. When the ac supply to the charger is interrupted, the battery shall supply the required power for the specific load duty cycle.

2.02 BATTERIES

A. Construction:

1. Batteries shall be of the Nickel-Cadmium type with a minimum of 20 years design life under normal usage for the intended duty. Batteries shall be designed for float service.

2. Batteries shall consist of a sufficient number of cells to provide a nominal output voltage of 125 V. For the purpose of these specifications, the nominal voltage is defined as the flat portion of the battery discharge characteristics at 1C rate, at 20 degrees C ambient temperature.

3. The battery shall be designed for float charge at 1.41 V/cell. The battery discharge cut-off shall be at 105 Vdc.

4. Recharging shall be at constant voltage, at a V/cell value as recommended by the battery manufacturer, and depending on the type of charging used (single rate or dual rate) and the ambient temperature.

5. The battery capacity for each type of substation shall be sized in accordance with IEEE 1115a.

6. Establish the required capacity in rated ampere-hours for an 8-hour discharge rate at 77 degrees Fahrenheit, and the end voltage in V per cell as required to meet the load cycle as described herein.

7. Be warranted to retain at least 80 percent of rated capacity for 20 years from the date of acceptance.

8. Do not vent gas under normal operation.

9. Each cell shall be provided with sealed pressure relief, explosion resistant vent, and flame arrester.

10. Cells battery shall be delivered dry charged. Accessories, including electrolytes, shall be packed in separate shipping cartons.

11. Cells shall be provided with inter-cell and inter rack connectors. Batteries shall be provided with terminal plates and lugs as required. Connector, plates, and lugs shall be lead-plated solid copper.

B. Battery Racks and Ventilation System:

1. Batteries shall be provided with two-tier two-step structural steel support racks. Racks shall be provided for seismic duty, complying with IBC requirements. 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.
2. Racks shall be treated with acid-resistant finish paint coat. See Section 09 97 13 – Steel Coatings, for further requirements.

3. The TPSS and GBS air ventilation systems shall be provided to remove all potentially explosive gases from the substation batteries and vent it directly to the outside. Coordinate the requirements of the substation ventilation with the battery supplied.

C. Industrial Mat: Electrolyte resistant plastic mat shall be provided under each battery rack, extending not less than 12 inches outside the rack.

D. Nameplates: Each battery cell container shall be marked with the following information:
   1. Manufacturer’s name
   2. Month and year of manufacture
   3. Cell type

E. Accessories: One set of the following accessories shall be provided for each battery system:
   1. Thermometer
   2. Cell lifting sling and spreader
   3. Battery log book
   4. Quart of terminal grease
   5. Set of special tools
   6. Set of cell identification numbers
   7. Main battery fuses and holders: Fuses shall comply with NEMA FU 1 and shall provide short circuit protection for the battery and cables to the dc distribution panelboard. Fuses shall be mounted adjacent to the battery rack, and shall be double-pole, pullout fuse block type.

2.03 BATTERY CHARGERS

A. Battery chargers shall be completely automatic, silicon-diode rectifier, convection cooled, and constant voltage, complying with NEMA PE 5.

B. Battery charger enclosure shall be NEMA 250, Type 1. Enclosure shall be provided with a hinged front panel complete with lockable handle and two-point latches, minimum.

C. Provide battery charger shutdown circuit from remote signal in accordance with ventilation requirements. See Section 34 20 01 – Traction Electrification - General Requirements and Section 34 20 05 –Prefabricated Enclosures, for further requirements.

D. Provide Temperature compensated charging circuitry.

E. Battery chargers shall be rated as follows:
   1. Capacity: In accordance with its associated battery size and continuous dc load
   2. Recharging: Battery recharge rate from 1.00 V per cell to 85 percent of the battery capacity in 8 hours, maximum
   3. Input Voltage: 208 V ac, 60 Hz, three-phase
4. Output Voltage: 125 V dc nominal, in accordance with specified battery voltage
5. Output Current: In accordance with associated battery size and continuous dc load
6. Regulation plus or minus 1 percent of output dc voltage over its complete load range with plus or minus 10 percent variation of input ac voltage
7. Current Limiting: Adjustable from 90 to 115 percent, factory set at 110 percent of output nominal current rating

F. Each battery charger shall be furnished with the following accessories:
1. One dc voltmeter, 0 to 200 V.
2. One dc ammeter, range as applicable.
3. One ac input pilot light marked AC POWER ON.
4. One selector switch two positions marked FLOAT and EQUALIZE.
5. Two ground detection alarm relays, positive and negative, for local and remote supervisory annunciation.
6. Alarm relays for Battery High and Low Voltage.
7. One ac input molded-case circuit breaker, NEMA AB 1.
8. One dc output molded-case circuit breaker, NEMA AB 1.
9. One equalizing time charger, 0 to 72 hours, to terminate a manually set adjustable equalizing charge of 1.65 V per cell.
10. One dc failure alarm relay device 127 for local and remote supervisory annunciation. The alarm contacts shall be coordinated with the requirements for annunciating on loss of power or trouble. See Article 2.06 herein, and the RFP Plans for further requirements.
11. One ac failure alarm relay device 227 for local and remote supervisory annunciation. The alarm contacts shall be coordinated with the requirements annunciating on loss of power or trouble. See Article 2.06 herein, for further requirements.
12. Space heaters, as required.

2.04 DC DISTRIBUTION PANELBOARDS

A. Provide two dc Panelboards complying with the requirements of NEMA PB 1, PB 1.1 and certified UL 67. They shall be suitable for 2-wire, 125 V dc and 24 V dc, respectively for ungrounded power distribution service. Panelboards shall be equipped with main and branch circuit breaker type disconnects complying with NEMA AB 1. Bus bars shall be ASTM B187, 98 percent conducting copper with silver plated contact surface.

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. Establish the required current rating of the control power distribution panelboards for each type of traction power substation or gap breaker station. Panelboards shall be furnished with main incoming terminals and disconnects for separate connection of battery and battery charger supplies and 125 V dc distributed power. Branch circuit breaker shall be a minimum of 100 Amps frame sizes with 10,000 Amps interrupting rating. See Section 26 05 33 – Raceway and Boxes for Electrical Systems and Section 26 24 16 – Panelboards, for further requirements.

E. The Panelboards shall be furnished with the required number of branch circuit disconnects based on the following control power distribution requirements:

1. 125 V dc Panelboard:
   a. Medium-voltage switchgear assembly
   b. Each dc power switchgear assembly
   c. Each ac-to-dc conversion assembly
   d. Each dc-to-dc conversion assembly
   e. Local PLC/Annunciator panel
   f. BLS/ETS on outside wall of TPSS and GBS
   g. Four spares

2. 24 V dc Panelboard:
   a. Local PLC/Annunciator panel
   b. Communications Interface Cabinet
   c. Provide four circuits with two circuits from one dc/dc converter source and the other circuit from a separate dc/dc source
   d. Four spares

F. A voltage monitoring relay manufactured by Potter and Brumfield type KRPA11DN110 or Agastat relay, or approved equal, device 27DC-B, as indicated in the RFP Plans, 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 PLC/Annunciator panel for local and remote supervisory annunciation. The relay shall be housed in a NEMA 1 enclosure and installed adjacent to the dc distribution panelboard. See Article 2.06 herein, for further requirements.

2.05 DC TO DC CONVERTERS

A. 125 V dc to 24 V dc converters shall be provided to power the devices including the Ethernet Edge Switch, the LCD Operators panel, and the PLC input/output within the TPSS and GBS.

B. The dc/dc converters shall be of an N-1 redundant design, such that a single failure of a converter shall not affect availability of 24-V dc to the devices served from performing there intended functions.

C. The converters shall be located within a separate enclosure within the TPSS and GBS to perform its required function.

D. These converters shall be provided with alarm contacts for annunciating on loss of power or trouble as indicated in the RFP Plans.

E. All dc/dc powered devices shall be installed with surge suppression devices and shall be voltage regulated to within 2 percent of the 125 V dc line voltage to maintain adequate stability to the dc system.
2.06 INITIAL PROVISIONING
   A. Each complete 125 V dc System including Battery, Battery Charger, dc/dc converter and panel board circuit breakers shall be provided with an itemized list of parts with quantities, order preference, and price that the Core Systems DBOM Contractor recommends for 2 years of operation before restocking. The reference number for each item shall include the Contractor’s and the original manufacturer’s part numbers. See Technical Provision TP-03, “O&M Performance Requirements” for further requirements.

2.07 SUPERVISORY CONTROL AND ANNUNCIATION REQUIREMENTS
   A. Remote supervisory control and annunciator circuits shall be provided for the dc power panels, the dc/dc Converters, and the battery charger to interface with the substation PLC/Annunciator panel. See Section 34 20 35 – Control and Annunciation System, and the RFP Plans for further requirements.

PART 3 – EXECUTION

3.01 INSTALLATION
   A. Battery cells shall be assembled on the battery racks, filled with electrolyte, and given an equalizing charge, following the installation of the prefabricated enclosure substation at the site.
   B. Install battery and specified equipment within each substation enclosure: secure, plumb, and level and in true alignment with related adjoining work. Install racks in accordance with Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems.
   C. Install supporting members, fastenings, framing, hangers, bracing, brackets, straps, bolts, and angles as required to set and rigidly connect the work.
   D. Battery cells shall be assembled on the battery racks and given an equalizing charge following the installation of the prefabricated unit substation at the site, but before the start of field testing.
   E. Battery intercell connectors shall be assembled, torqued, and tested in accordance with the battery manufacturer’s specifications. The completed battery shall have the intercell connectors tested with a micro-ohmmeter. Any intercell connector that fails the manufacturer’s specified requirement by 20 percent shall be disassembled, cleaned, prepared, reassembled, and re-tested until it tests within the specified limits.
   F. Ground all equipment in accordance with NFPA 70 National Electrical Code and in accordance with Section 26 05 26 – Grounding and Bonding for Electrical Systems.

3.02 TESTING
   A. See Section 26 08 10 – Testing of Electrical Systems and Section 34 20 80 – Traction Electrification System Testing, for further requirements.
   B. See Technical Provision TP-02, “Verification Testing and Acceptance” for further requirements.

END OF SECTION
PART 1 – GENERAL

1.01 SUMMARY

A. Description: This Section includes for providing basic materials and devices used in traction power facilities. This Section supplements the Work specified in other Sections for the traction power facilities.

B. Section Includes:

1. Meters and Relays
2. Transducers
3. Switches
4. Wires and Cables
5. Raceways
6. Wiring Devices
7. Indicating Lights
8. Buses and Connections
9. Panelboards
10. Fused Disconnect Switch
11. Electric Service Meter Panel
12. Electric Service Instrument Cabinet
13. Miscellaneous Devices
14. Initial Provisioning

C. Related Sections:

1. Section 26 05 00 – Common Work Results for Electrical
2. Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables
3. Section 26 05 33 – Raceways and Boxes for Electrical Systems
4. Section 26 08 10 – Testing of Electrical Systems
5. Section 26 27 26 – Wiring Devices
6. Section 26 28 13 – Fuses
7. Section 34 20 01 – Traction Electrification - General Requirements
8. Section 34 20 05 – Prefabricated Enclosures
9. Section 34 20 10 – AC Switchgear
10. Section 34 20 25 – DC Switchgear
11. Section 34 20 80 – Traction Electrification System Testing

1.02 PRICE AND PAYMENT PROCEDURES

A. General: Separate measurement or payment will not be made for the Work required under this Section. All cost in connection with Work specified herein will be considered to be included with the related item of work in the General Conditions requirements, or incidental to the Work.

1.03 CODES, STANDARDS, AND RECOMMENDED PRACTICES

A. American National Standards Institute (ANSI):
   1. ANSI 232-F Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange
   2. ANSI C37.41 Design tests for Power Fuses

B. Institute of Electrical and Electronics Engineers (IEEE):

C. National Electrical Manufacturers Association (NEMA):
   1. NEMA WC70/ICEA S-95-658 Standard for Non-Shielded Power Cables Rated 2,000 Volts or Less for the Distribution of Electrical Energy
   2. NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum), Type 3R

D. National Fire Protection Association (NFPA):
   1. NFPA 70 National Electric Code

1.04 SUBMITTALS

A. General: Refer to General Conditions requirements for Submittal Procedures, and for Shop Drawings, Product Data, and Samples requirements and procedures.

B. Submit all data, design plans, procedures and samples in accordance with Section 34 20 01 – Traction Electrification - General Requirement, submittal requirements including, but not limited to the following:
   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.


5. Training Manuals and Equipment: Training manuals and equipment shall conform to the requirements of the Management Provisions and Technical Provision TP-03, “O&M Performance Requirements”.

1.05 QUALITY ASSURANCE

A. General: Refer to General Conditions requirements for quality assurance requirements and procedures.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As the Miscellaneous Materials and Devices are to be installed within the Prefabricated Enclosure and other areas of the Traction Electrification System (TES), the Core Systems Design-Build-Operate-Maintain (DBOM) Contractor shall coordinate the delivery, storage, and handling of the these Miscellaneous Materials and Devices with the requirements as they apply to their respective areas described in Sections 34 20 01 – Traction Electrification - General Requirements and Section 34 20 05 – Prefabricated Enclosures.

1.07 WARRANTY

A. The Core Systems DBOM Contractor suppliers shall warrant that their products are free from defects. Warranty shall conform to the requirements of the General Conditions requirements.

PART 2 – PRODUCTS

2.01 METERS AND RELAYS

A. Interposing (Auxiliary) Relays:

1. Interposing (auxiliary) relays shall be plug-in type and include dust covers and be rated for 10 amperes.

2. Relay coil shall be able to pickup by momentary contact closure of 300 ms and its contacts shall stay closed until the breaker or the end device completes its operation. If operation is not completed within the normal time, the relay coil shall reset automatically.

3. All signals to the SCADA system within the TPSS and the GBS shall be transmitted by the PLC and through the Multifunction Relays (MFPR) as specified in Section 34 20 25 – DC Switchgear and Section 34 20 10 – AC Switchgear. Where interposing relays are to be used for discrete signals, the duration of the pickup times of the remote control signals through the substations Programmable Logic Controller
(PLC) and interposing relays shall be tested to ensure the remote commands do reach and activate the end device of the intended equipment.

B. Meters: All meters shall be integrated within the MFPR. Where the Contractor elects to provide independent meters, they shall be digital switchboard type for semi-flush mounting. The cases shall be dust tight, with dull black finish, and covered with a non-reflecting glass window. They shall meet the following requirements:

1. Ammeters, wattmeters, watthour meters, varhour meters, and voltmeters shall be solid-state type with digital LED readouts that cover the full range of operation including overload conditions. The LED readouts wattmeters, watthour meters, and varhour meters shall be able to read 9 digits and self-reset to zero after maximum reading is reached. The ammeters and voltmeters shall have sufficient number of digits to display currents and voltages within plus/minus 1 A and plus/minus 1 V resolution, respectively. They shall also include analog style display features and comply with ANSI 232-F standard.

2. The accuracy of all indicating instruments shall be within 1/2 percent of the actual value. The indicating instruments shall have true root mean square (rms) sensing.

3. AC voltmeters shall be 3-phase type suitable for 4-wire input, and shall be connected to the secondary windings of three potential transformers that are connected phase to neutral. The calibration shall be in primary voltage units, and the voltmeter shall have a built-in selector switch to allow display of either Line-Neutral or Line-Line voltages. The three L-N or L-L voltages may be displayed either simultaneously or one at a time, in the latter case through a built-in selector switch. DC voltmeters shall receive inputs from voltage transducers as specified. Input voltage range to the transducers shall be 1,500 V.

4. AC ammeters shall be rated for operation with the connected current transformers. DC ammeters shall be rated for use with metering shunts, as indicated. Ammeters shall be properly protected to prevent damage due to the flow of maximum available short-circuit current in the primary system.

5. Where independent ammeters and voltmeters are provided, they shall be provided with analog indicating type display and digital communication outputs. They shall be used to send the metering data to the PLC for remote indication at the Traction Electrification System traction power facility, for local display on the LCD screen and for re-transmission to the SCADA System. The scan rate for remote indication shall be 1 second.

6. DC current and voltage measurement for the dc feeder circuits shall be provided, with both current and voltage continuously displayed, as indicated in the RFP Plans. The dc feeder current and voltage measurements shall be also sent to the PLC for display.

7. Power supply for all meters shall be derived from the station battery.

8. Wattmeters shall be rated 1 mA for connection to wattmeter transducers.

9. The kilowatt demand and kilowatt-hour device function No. 298 for TPSS facilities, as indicated in the RFP Plans. It shall be of draw out construction and shall be transformer rated with suitable range equal to the associated potential and current transformers. The meters shall be furnished with an accumulator for kwhr, kilowatt
power demand with peak demand reset function, and remote output and local indication of measurements. Devices shall comply with IEEE 37.90 and 37.91 standards.

10. For GBS facilities, provide a wattmeter within the prefabricated enclosure at AC Panel L01 with output to the PLC as specified in Section 34 20 35 – Control and Annunciation System, and the RFP Plans.

2.02 TRANSDUCERS

A. Temperature Transducer:

1. The temperature input range shall be coordinated with type of Resistance Temperature Detector supplied with the rectifier transformer.

2. The output range shall be suitable for the temperature class of the rectifier transformers.

3. Transducers shall be either 4 to 20 mA dc, or 1 to 5 V dc signals

2.03 SWITCHES

A. Control and Selector Switches:

1. Control and selector switches shall be rotary, cam-operated, multi-stage type, suitable for switchboard mounting with a rectangular, front panel engraved escutcheon plate showing the switch positions. The switches shall be Westinghouse type W-2, or General Electric type SB-1, or approved equal.

2. Each control switch shall have the indicated below type of handle:
   a. All circuit breaker control switches shall have pistol-grip handles.
   b. All instrument selector switches shall have round knurled handles.
   c. Lockout relays and local-remote transfer selector switches shall have oval handles.

3. Switch contacts shall be silver-plated, self-cleaning, readily renewable type, and shall have adequate insulation and contact surface. Switches shall be installed so that mating contact surfaces are parallel.

4. Breaker control switches shall be spring-return to neutral type, and shall be furnished with mechanical indicating devices (red and green target) to show the last operation of the switch.

5. Determine the number of stages and contact wiring arrangement for each switch, depending on the application. Each switch shall be provided with at least two spare stages.

6. Switches shall be rated for a mechanical life of not less than 500,000 operations. Electrical ratings shall be 600 V, 20 A continuous.

7. Tight-fitting dust covers shall keep the operating and contact parts of the switches clean.
B. Test Switches:
   1. Test switches shall be provided for all ammeters and voltmeters, and between all instrument transformers and the protective relays supplied by them.
   2. Each test switch group shall be mounted in a semi-flush case of uniform size, capable of holding at least six current positions and four voltage positions. A convenient, dull black cover shall permit covering the test switches and contacts when they are not in use.
   3. At the switching stations, test switches in current transformer circuits shall be 7-pole, with three straight test jack assemblies, one through bar, and three single-pole current assemblies, left hand, working as one unit.
   4. Test switches for the current transformers shall be of the type that do not disturb the permanent wiring and do not interrupt the current transformer circuit when the switch is used.
   5. The test switches shall be specifically designed for use in ac instrumentation circuits, and shall be UL listed. Test switches shall be by States, Superior, Meter Devices, or approved equal.

2.04 Wires and Cables

A. Low voltage power and control wiring and cables shall have insulation rated for continuous operation at 600 volts minimum and comply with NFPA 70 regulation. Refer to Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables, for the requirements for 600-volt single and multiple conductor power and control cables, fixture wires, thermocouple cables, color-coding of conductors, cable supports and fasteners, and conductor bundling straps. Additional requirements shall be as follows:
   1. Switchboard wiring shall be type Synthetic Insulated Switchboard (SIS).
   2. Wire that crosses hinged joints shall be flexible Class C stranded copper, hinge-type wire.
   3. Cables shall have the manufacturer, type of insulation and voltage class identified by continuous labeling, that shall remain legible for the life of cable under normal use in service.
   4. Cables shall pass the flame propagating criteria of IEEE 383 and shall have a minimum circuit time of five minutes in the flame test of IEEE 383. Type test certificate shall be included with every shipment of cables.

B. 2,000-Volt Control Wire and Cable:
   1. Control wires and cables with 2,000 V insulation - referred to also as HV control power cables - shall be single conductor, copper, and Class B stranded. High-voltage control power cables shall be used for control and instrumentation circuits exposed to the 1,000 V potential, and shall feature warning signs and tags. Cables shall meet W70/ICEA S-95-658 requirements.
   2. The termination accessories shall be furnished in the form of a kit and shall include complete instructions.
C. Terminal Connectors, Splices and Insulating Tapes:

1. Termination fittings for No. 10 and smaller conductors shall be screw-on, spring pressure type copper connectors with nonflammable, self-extinguishing insulation of temperature rating equal to that of cable being connected. Terminals shall provide a metal grip on the conductor insulation for strain relief. Wire nuts are prohibited.

2. As approved by the City, splices shall be kept to a minimum and are prohibited in locations other than handholes and pullboxes for non-critical circuits. All splices underground in handholes or other wet locations shall be waterproof and made with Scotchcast 85 Multi-Mold Splicing Kits, or approved equal.

3. All tape shall be 3M Scotch Brand vinyl plastic electrical tape or approved equal.

2.05 RACEWAYS

A. Requirements for interior conduits, fittings and accessories, conduit hangers, inserts, outlet, junction, cable trays, and pull boxes shall be in accordance with Section 26 05 33 – Raceway and Boxes for Electrical Systems.

B. Raceways external to traction power facilities shall be in accordance with Section 34 20 51 – Traction Electrification System Interface Requirements, and Section 34 20 65 – Traction Power Raceways.

2.06 WIRING DEVICES

A. Toggle switches, receptacles, and associated covers, shall comply with the requirements of Section 26 27 26 – Wiring Devices.

B. Terminal Blocks:

1. The terminal blocks shall be 600 volt, heavy-duty, screw washerhead type with laminated phenolic dust covers and adhesive-backed marking strips to indicate the wire numbers.

2. Current and potential transformer secondary leads shall be wired directly to the terminal blocks before wiring them to the relaying, metering or control devices.

3. Terminal blocks for current transformer leads shall be of the short-circuiting type.

4. The common secondary of the current and potential transformers shall be grounded with No. 8 America Wire Gauge wire running directly to the ground bus without intervening splices or terminal blocks.

5. Terminal blocks shall be grouped by cable designation and segregated according to the circuit voltage.

6. Identification of terminal blocks and terminal points shall be alphanumeric with each terminal block having a unique identification.

7. Each terminal block or terminal block group shall have at least 20 percent spare points.

C. Generator Receptacle: Provide a 4-pole generator receptacle in compliance with the UL standards and having the grounding contact pole connected through a factory installed
grounding strap to ground the portable generator. The receptacle shall be sized pursuant to the TPSS and GBS prefabricated enclosure electric loads and the generator the CSC will provide per the Technical Provision TP-03 “O&M Performance Requirements.”

2.07 INDICATING LIGHTS

A. Indicating lights on all equipment in the traction power facilities shall be based on LED lamps. The LED lamps shall be replaceable, with built-in resistor and high dielectric strength for reverse voltage protection. The LED lamps shall be:

1. Suitable for use with either 125 V dc, or 24 V dc, depending on the control system voltage
2. Capable of operating over a voltage range from plus 15 percent to minus 30 percent of the nominal
3. Designed with bayonet bases
4. Mounted in compact, rugged sockets
5. Readily replaceable from the front

B. Lenses and bezels shall be rectangular or circular, 1-3/8 inch maximum width and height and shall permit reading from oblique angles.

C. LEDs shall be rated for 100,000 hours at full voltage, and shall be clearly visible at an angle of 30 degrees and at a distance of 15 feet in a fully lit environment.

2.08 BUSES AND CONNECTIONS

A. Buses shall be made of round edge rectangular, high conductivity, rigid copper bars and shall be of sufficient size to carry the continuous rated current, without exceeding the temperature limits indicated in the applicable ANSI, NEMA, and IEEE standards for the specific equipment.

B. The buses shall be supported and braced between each other and to the enclosure with high strength anti-hygroscopic, flame retardant, non-tracking insulators, so that the buses can withstand the thermal and mechanical stresses due to short-circuit currents equal to the maximum symmetrical interrupting and 3-second short time current ratings of the circuit breaker protecting the bus.

C. Bus taps and connections shall be welded or bolted:

1. All bolted bus connections shall be acid etched and plated with electro-deposited silver after buses have been bent or formed. Bending after the plating process is not allowed.

2. Bolted connections shall utilize Bellville-type washers and high strength, rust resistant steel bolts, such as cadmium-plated or galvanized. Bolts shall pass through the bus bar conductors, and shall be capable of being properly torqued and locked in place, to provide and maintain full and uniform pressure under all operating conditions.

D. Bus joints shall have conductivity at least equal to that of the bus bar, and each joint shall be so clamped that no loss of conductivity will occur during the life of the equipment.
E. Access plates shall be provided to permit assembling joints and inspecting all bolted connections after installation of the bus enclosure.

2.09 PANELBOARDS
A. Panelboards shall conform to Section 26 24 16 – Panelboards.

2.10 FUSED DISCONNECT SWITCH
A. Provide fused disconnect switches in accordance with Section 26 28 16 – Enclosed Switches and Circuit Breakers.

2.11 ELECTRIC SERVICE METER PANEL
A. Provide surface mounted single meter position enclosed panel with internal arrangement and mounting designed to receive watt-hour meters that meet HECO requirements.
B. Enclosures shall be UL listed, weatherproof with a NEMA 3R rating, and meet HECO requirements.
C. Outer door shall be provided with HECO approved double locking mechanism with provisions for sealing by the utility company.
D. Provide panel with adequately sized bonding post.

2.12 ELECTRIC SERVICE INSTRUMENT CABINET
A. Provide surface mounted enclosed instrument cabinet, with internal arrangement designed to mount the utility supplied instrument transformers on brackets with adequate space for cabling per HECO service.
B. Enclosures shall be UL listed, weatherproof with a NEMA 3R rating.
C. Provide service entrance label and necessary applicable service entrance features.
D. Provide ingress and egress knockouts positioned on diagonally opposite corners of the cabinet.

2.13 MISCELLANEOUS DEVICES
A. Space Heaters: Thermostatically- and humidistatically-controlled space heaters shall be provided in all enclosures, and in separate compartments within enclosures, to keep the equipment temperature above the dew point and avoid condensation. Space heaters shall operate from the 120 V, single-phase, 60 Hz supply, and the circuits shall be protected by circuit breakers. Space heaters shall be provided with laminated phenolic nameplates.
B. Current-Limiting Fuses: Current-limiting fuses shall be installed in all control and instrument circuits at the points of supply as indicated in the Contract Documents:
   1. Fuse mounts shall be porcelain, bakelite or molded phenolic base, with appropriate voltage rating so that the fuse mount does not represent a weak point of the overall insulation system. Fuses shall comply with ANSI C37.41 requirements.
2. The fuses and resistors shall be housed in an enclosure made of electrical-grade laminated phenolic having a minimum wall thickness of 1/4 inch and covering all live terminals.

3. The fuses shall be readily accessible and shall not obstruct or be obstructed by any other equipment.

4. See Section 26 28 13 – Fuses, for further requirements.

C. Current Shunts: current shunts shall be used to provide dc millivolt signals as input to current measuring instruments and relays, as indicated on the RFP Plans. Current shunts shall be of rugged design and suitable for in-line busbar mounting. Shunt output shall be 50 mV nominal, with accuracy plus or minus 0.25 percent. Determine the current rating of the shunt, as suitable for the application.

2.14 INITIAL PROVISIONING

A. Each complete component and assembly shall be provided with an itemized list of parts with quantities, order preference, and price that the Contractor recommends for 2 years of operation before restocking. The reference number for each item shall include the Contractor’s and the original manufacturer’s part numbers. See Technical Provision TP-03, “O&M Performance Requirements” for further requirements.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Installation of the traction power materials and devices shall conform to the recommended practices of the applicable ANSI, IEEE, NFPA, and NEMA standards; shall be in accordance with the accessibility, clearance, conformity, and arrangement requirements of Section 34 20 01 – Traction Electrification - General Requirements, and Section 34 20 05 – Prefabricated Enclosures.

B. Installation of electric meter instrument transformer cabinets and fused disconnect switch for the Gap Breaker Stations shall be as described herein:

1. Install fused disconnect switch and exposed raceways and cables as indicated on RFP Plans on outside wall of the GBS.

2. Install meter socket and exposed raceways as indicated on outside wall of the GBS.

3. Install instrument transformer cabinet and exposed ingress and egress raceways on outside wall of the GBS. The instrument transformer cabinet shall be on the line-side of the main disconnect per HECO requirements unless approved otherwise by the City.

4. Instrument transformer cabinet ingress and egress conduits shall be positioned diagonally opposite corners of the cabinet.

5. Mount enclosures and cabinets secure and plum per approved HECO installation design plans.

6. Provide sufficient clearances between the meter socket enclosure and the instrument transformer cabinet in accordance with HECO service requirements.
7. Make no cable splices or feeder taps within the enclosure and cabinet.

8. Coordinate with the GBS supplier for providing mounting of cabinets and penetrations of the GBS wall.

9. Make no splices or feeder taps within cabinets.

10. Provide sufficient sealant compounds to prevent water penetration into GBS.

3.02 TESTING

A. General: All testing shall be carried out in accordance with the requirements of Section 26 08 10 – Testing of Electrical Systems, and Section 34 20 80 – Traction Electrification System Testing.

B. Unless otherwise indicated, design tests on traction power materials and devices that are standard products of manufactures, or off-the-shelf items, are not required.

C. See Technical Provision TP-02, “Verification, Testing, and Acceptance” for further requirements.
SECTION 34 20 55
WAYSIDE DC DISCONNECT SWITCHES

PART 1 – GENERAL

1.01 SUMMARY

A. Description: The Work of this Section includes for providing the design, procurement, and installation of Electrically Operated dc Disconnect Switches (EOS) and related accessories for the Maintenance and Storage Facility (MSF) Yard as indicated in the RFP Plans and specified herein.

B. Section Includes:
   1. General
   2. Disconnect Switch Contact Ratings
   3. Construction
   4. Initial Provisioning
   5. Supervisory Control and Annunciation Requirements

C. Related Sections:
   1. Section 26 05 00 – Common Work Results for Electrical Systems
   2. Section 26 08 10 – Testing of Electrical Systems
   3. Section 34 20 01 – Traction Electrification - General Requirements
   4. Section 34 20 52 – Traction Electrification System MSF Interface Requirements
   5. Section 34 20 80 – Traction Electrification System Testing

1.02 PRICE AND PAYMENT PROCEDURES

A. General: Separate measurement or payment will not be made for the Work required under this Section. All cost in connection with Work specified herein will be considered to be included with the related item of work in the General Conditions requirements, or incidental to the Work.

1.03 CODES, STANDARDS, AND RECOMMENDED PRACTICES

A. American National Standards Institute (ANSI):
   1. ANSI C37.34 Test Code for High-Voltage Air Switches
   2. ANSI Z55.1 Gray Finishes for Industrial Apparatus and Equipment

B. ASTM International (ASTM):
   1. ASTM B187 Standard Specification for Copper, Bus Bar, Rod, and Shapes and General Purpose Rod, Bar, and Shapes

C. Institute of Electrical and electronic Engineers (IEEE):
D. National Electrical Manufacturers Association (NEMA):

1. NEMA 250 Enclosures for Electrical Equipment (1,000 Volts Maximum), Type 3R
2. NEMA ICS 1 Industrial Control and Systems General Requirements
3. NEMA ICS 2 Industrial Control and Systems Controllers, and Overload Relays rated not more than 2,000 V ac or 750 V dc
4. NEMA SG 5 Power Switchgear Assemblies

E. National Fire Protection Association (NFPA):

1. NFPA 70 National Electrical Code (NEC)

1.04 PERFORMANCE REQUIREMENTS

A. General: Prior to design, procurement, and installation coordinate with the Yard MSF Contractor and confirm the Traction Electrification and communication requirements for developing the final design.

B. Furnish all labor, materials, tools, and equipment to perform the following:

1. Provide EOS for control of the positive power feed to the Contact Rail within the MSF Yard as indicated in the RFP Plans.

2. Coordinate the manufacture of the EOS with interface requirements for conduit stub ups and the switch pad installed by the MSF Design Build Contractor as indicated in the RFP Plans and Section 34 20 52 – Traction Electrification System MSF Interface Requirements.

3. The EOS control operating mechanism shall be provided with 480 Vac circuits from a Power Panel located within the MSF Operations & Servicing building. Provide and install all necessary interface components including electrical contacts within the EOS enclosure to operate the unit from the MSF Operations and Servicing building, OCC Communications Equipment Room, and Yard Control Tower. The coordination shall consider voltage drop in the design, procurement, and installation of the EOS units. Circuit components selected shall facilitate proper operation of the EOS units controlled from the Yard Control Tower as required in accordance with Article 2.05 herein, and as indicated in the RFP Plans.

4. Provide No Load Break type EOS units and interlocks to prevent the EOS from operating under load, under any circumstance.

5. Provide handle to manually operate the switch in the event of loss of control or operating power. The handle shall not be operable if the switch is under load.

6. Ground rods will be provided and it is the Contractor’s responsibility to provide a connection point of the ground cable within the EOS unit as required by the manufacturer of the switch.

7. See Section 26 05 00 – Common Work Results for Electrical and Section 34 20 01 – Traction Electrification - General Requirements, for further requirements.
1.05 SUBMITTALS
A. General: Refer to General Conditions requirements for Submittal Procedures, Shop Drawings, Product Data, Sample requirements, and procedures.

B. Submit the following in accordance with Section 34 20 01 – Traction Electrification - General Requirements:

1. The following submittals shall receive the City's approval prior to fabrication:
   a. Complete manufacturer's descriptions, marked catalog data cut sheets, and information including model number
   b. Manufacturer’s general and detail arrangement drawings, and installation instructions
   c. Electrical schematic and wiring diagrams
   d. Operation and maintenance manual with list of recommended spare parts

2. Submit qualification and production test reports within 1 week after completion of each component testing procedure.

3. Supply operating and maintenance manuals for the EOS Disconnect Switches. These manuals shall include.
   a. Descriptions, specifications, theory of operation, layout drawings, assembly wiring diagrams, and other electrical and mechanical hardware data.
   b. Instructions for preventative maintenance procedures that consist of examinations, tests, adjustments, and periodic cleaning to be performed under normal and abnormal operating conditions.
   c. Guidelines for isolating the cause of an equipment malfunction and troubleshooting to localize faults.
   d. Instructions for the set-up and operation of all components, as it is configured in the EOS Disconnect Switch.
   f. Training Manuals and Equipment: Training manuals and equipment shall conform to the requirements of the Management Provisions.

1.06 QUALITY ASSURANCE
A. General: Refer to General Conditions for quality assurance requirements and procedures

B. Comply with all applicable Federal, State, and Local Laws, Regulations, and Codes including those referenced in Article 1.03.

1.07 DELIVERY, STORAGE, AND HANDLING
A. Ship each item of equipment and materials securely wrapped, packaged, and labeled for safe handling in shipment and to avoid damage.

B. Store equipment and materials in secure and dry storage facility.

C. Provide loose components securely tied down during shipment.

D. Provide Shipping splits considering the following restrictions:
   1. Site limitations
2. Transportation considerations

1.08 WARRANTY

A. The Core Systems Design-Build-Operate-Maintain (DBOM) Contractor suppliers shall warrant that their products are free from defects. Warranty shall conform to the requirements of the General Conditions.

PART 2 – PRODUCTS

2.01 GENERAL

A. The bolted pressure outdoor type, no-load type, EOS shall be non-fusible, single-pole, single-throw switches, with electrical motor operators including control functions for local/remote selector switches, and open/close pushbuttons. The EOS shall be an enclosed type, suitable for PAD mounting. Design shall comply with the applicable requirements given in ANSI C37.34 and Z55.1, ASTM B187, NESC, NEMA 250, SG 5, ICS 1, and ICS 2.

2.02 DISCONNECT SWITCH CONTACT RATINGS

A. No-load break type switches shall have the following ratings:

1. Maximum Operating Conditions:
   a. Voltage:
      1) Normal Max.: 1,250 V dc
      2) Insulation Level: 3,000 V, rms, minimum for one minute
   b. Current:
      1) Continuous Max: 3,000 Amps dc
      2) Momentary Withstand: Not less than 180 kA rms

2. Heat Rise: 122 degrees Fahrenheit rise above a maximum ambient temperature of 104 degrees Fahrenheit

3. Normal Operating Conditions:
   a. Nominal Voltage: 775 V dc
   b. Continuous Current: 2,500 AMPS

2.03 CONSTRUCTION

A. Electrically Operated Disconnect Switch Assembly:

1. Each switch shall be furnished with an electrical operator, local/remote control selector switch, open/close pushbuttons, relays, fully open and fully closed switch position auxiliary contacts, removable crank to manually operate the switch in case of loss of control power. Switch positions shall be indicated with clearly visible “OPEN” and “CLOSED” signs. An on/off selector switch shall be provided to shut off control power to the disconnect switch.

2. Provide a protective see through deadfront transparent non-conducting panel mounted in front of all current carrying components.

3. Provide a clear window in enclosure door for viewing internal components.
4. Local/Remote control selector switch, and open/close pushbuttons shall be installed on the face of the enclosure behind a locked hinged cover to prohibit unauthorized personnel from operating the switch.

B. Switch Main Contacts: Moving and stationary contact surfaces shall be silver plated copper. All other current-carrying parts shall be of high-conductivity copper or copper alloy. Contacts shall be self-aligning, wear-compensating, and with initial wiping action.

C. All non-current carrying metal parts shall be hot-dip galvanized steel.

D. Electrically operated gear motor operator:
   1. Switch Safety Interlocks – No-load break type switch safety interlocks shall be provided to prevent switch contact movement when front access door is in open position.
   2. Provide solenoid and locking circuits to prevent access to inside of enclosure when voltage presence sensor is detected on either side of switch. In addition, the sensors shall provide contacts for remote indication of voltages presence at each side of the disconnect switch.
   3. Provide external light emitting diode lamps indicating the disconnect switch positions and the power source availability of the control circuit.

E. Cable Termination:
   1. Power: The line and load side disconnect switch terminals shall be furnished with silver plated copper buses complying with ASTM B187, to accommodate the number and size of copper cables as indicated on the RFP Plans. The switch terminals shall have provision for 4-hole drilled NEMA rated cable terminal lugs.
   2. Indication:
      a. Terminal block and limit switch devices shall be provided for providing position indications of the switch contacts. Cabling from the Limit switch to the terminals shall be factory installed with wires rated at 2 kV.
      b. Wiring gutters shall be installed within the switch compartment to provide separation of incoming field cables running to the terminating blocks. The gutters shall be rated at an insulating level of 2 kV.
   3. Cable Entry: As shown on RFP Plans, the positive power feed cables to the EOS shall be bottom entry through conduit stub ups.
   4. As shown on RFP Plans, the positive power feed cables from the EOS to the Contact rail shall be by bottom entry of the EOS.

F. As shown on RFP Plans, all control cables shall be bottom entry. The EOS shall provide for adequate safety separation barriers between the power, control, and indicating circuits.

G. Switch Enclosures:
   1. Construction:
      a. Outdoor type: NEMA 3R Rain tight construction suitable for outdoor mounting.
      c. Materials: Non-metallic box and a minimum of 1/4 inch thick polyester with a glass to resin ratio of 30 to 70.
d. Window: On the front face of the switch door, install a clear flame retardant window for viewing the switch contacts position. The window shall be sealed from water penetration and provide Personal Safety during an ARC Flash condition.

2. Dimensions: Sized to accommodate the switch internal linkages operating gear, switch contacts and cabling terminations and to allow easy access to maintain the components through the door opening for the manipulation of service and installation tools.

3. Handle: Manual operating handle shall be provided in each unit to manually operate the disconnect switch.

4. Door: Gasketed hinged door catch, full-length stainless steel hinge. Adjustable doorstop hook to keep door from swinging out.

5. Rain Shield: Shield on switch front including where back cable entry is required. Top of enclosure shall be sloped to curtail water puddling.

6. Security: Padlock for each enclosure, all keyed alike. Quantity of keys and the lock style shall be as approved by the City.

7. Nameplates: Each switch shall have a permanent weatherproof identification name plate attached at a suitable location near the switch handle. The nameplates shall have the switch identification number in accordance with Section 34 20 01 – Traction Electrification - General Requirements.
   a. Switch Position: As indicated on the RFP Plans, handle alignment with Large and visible located on side of the Switch “OPEN” and “CLOSED”
   b. EOS Identification: On front face identifying the EOS locations
   c. Warning:
      1) “775 Vdc Normal Operating Voltage”
      2) “DO NOT Operate Manually Under Load”


9. Grounding: Provide appropriately sized ground buss for components that require grounding provisions to meet the reference standards cited herein.

2.04 INITIAL PROVISIONING

A. Each complete Wayside dc Disconnect Switch assembly shall be provided with an itemized list of parts with quantities, order preference, and price that the Contractor recommends for 2 years of operation before restocking. The reference number for each item shall include the Contractor’s and the original manufacturer’s part numbers. See Technical Provision TP-03, “O&M Performance Requirements” for further requirements.

2.05 SUPERVISORY CONTROL AND ANNUNCIATION REQUIREMENTS

A. The EOS shall be provided with a control compartment with terminal blocks, relays, and control components wired to allow for interfacing with the MSF Operations and Servicing building, OCC Communications Equipment Room, and Yard Control Tower control and indicating system.
B. The installed components shall allow for remote operation of the EOS to open and close through remote command from the Yard Control Tower control and indicating system.

C. Contacts shall also be provided for interfacing to the Yard Control Tower control and indicating system for indication of local/remote and open/close disconnect switch position, and the presence of 750 V dc at either side of the disconnect switch as indicated in the RFP Plans.

D. See the RFP Plans, and the Division 27 and Division 34 Technical Provisions Sections, for further requirements of the control and annunciation requirements.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Switches shall be field installed on concrete pad structures furnished by others as shown on the RFP Plans and specified herein. Field mounted switches shall be installed in accordance with the manufacturer’s instructions. Bolts and support items shall be provided as required.

B. Prior to energizing of the Contact Rail, verify correct operation of all disconnect switches installed under this Contract, and demonstrate to the satisfaction of the City the intended operation.

C. All wiring shall be provided as required. Conductor sizes, composition, and insulation shall be as indicated on the RFP Plans. All necessary additional hardware such as bushings, connectors, grounding conductors, all basic electrical materials needed for the installation of the equipment and accessories shall be supplied and installed by the Contractor.

D. The installation shall conform to the NEC and NESC requirements.

3.02 TESTING

A. See Section 26 08 10 – Testing of Electrical Systems and Section 34 20 80 – Traction Electrification System Testing, for further requirements.

B. See Technical Provision TP-02, “Verification, Testing, and Acceptance” for further requirements.

END OF SECTION
PART 1 – GENERAL

TRACTION POWER CABLES

1.01 SUMMARY

A. Description: The Work of this Section includes the requirements of the Core Systems Design-Build-Operate-Maintain (DBOM) Contractor final design, procurement, and installation of the dc Traction Electrification Systems (TES) Traction Power Cables, assemblies, and appurtenances as indicated in the RFP Plans for the following:

1. Traction Power dc Power positive and negative feeder cables from the Traction Power Substation (TPSS) to the Guideway Contact Rail
2. Traction Power dc Power positive and negative feeder cables from the Gap Breaker facilities (GBS) to the Guideway Contact Rail
3. Traction Power rail reference cables from the GBS to the Guideway running rail
4. Traction Power dc Power positive and negative feeder cables from the Maintenance and Storage Facility (MSF) Yard TPSS to the Yard Contact Rails
5. Traction Power dc Power positive and negative feeder cables for Contact Rail jumpers and shunts
6. Contact Rail Cable Connection Plates for feeder cables and jumpers
7. Contact Rail Connection block assemblies
8. Traction Power dc Power positive feeder cables from the Wayside dc Disconnect Electrically Operated Switches (EOS) to the MSF Yard Contact Rails
9. Low Voltage Power, Control, and Indication Cables from the EOS to the MSF Operations and Service Building Operations Control Center (OCC) communications equipment room.
10. Cables from the TPSS and GBS to Handholes for the Corrosion Control drainage cables as indicated in the RFP Plans.
11. Coordination of the installation of the communications Fiber Optic Cable Network for TES related operations of the Emergency Trip System and Transfer Trip Systems at the Mainline and MSF Yard as indicated in the RFP Plans.

B. Section Includes:

1. General
2. DC Power Cables (2.4kV)
3. 600 Volt Single Conductor Cable
4. Multiconductor Cable
5. Miscellaneous Materials

C. Related Sections:

1. Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems
2. Section 26 08 10 – Testing of Electrical Systems
3. Section 26 42 01 – Corrosion Control and Cathodic Protection
4. Section 34 20 01 – Traction Electrification - General Requirements
5. Section 34 20 18 – Traction Electrification System MSF Grounding Requirements
6. Section 34 20 19 – Traction Electrification System Grounding Requirements
7. Section 34 20 25 – DC Switchgear
8. Section 34 20 51 – Traction Electrification Systems Interface Requirements
9. Section 34 20 52 – Traction Electrification Systems MSF Interface Requirements
10. Section 34 20 70 – Traction Electrification Systems Interface
11. Section 34 20 80 – Traction Electrification System Testing

1.02 PRICE AND PAYMENT PROCEDURES

A. General: Separate measurement or payment will not be made for the Work required under this Section. All cost in connection with Work specified herein will be considered to be included with the related item of work in the General Conditions requirements, or incidental to the Work.

1.03 CODES, STANDARDS, AND RECOMMENDED PRACTICES

A. Association of Edison Illuminating Companies (AEIC):
   1. AEIC CS8 Specification for Extruded Dielectric, Shielded Power Cables Rated 5 through 46 kV

B. American National Standards Institute (ANSI):
   1. ANSI/ASC Alloy and Temper Designation Systems for Aluminum H35.1-6106-T6

C. ASTM International (ASTM):
   1. ASTM A325 Specification for High-Strength Bolts for Structural Steel Joints
   2. ASTM B3 Specification for Soft or Annealed Copper Wire
   3. ASTM B8 Specification for Concentric-Lay-Stranded Copper Conductor, Hard, Medium, or Soft
   4. ASTM B173 Standard Specification for Rope-Lay-Stranded Copper Conductors Having Concentric-Stranded Members, for Electrical Conductors
   5. ASTM B496 Specification for Compact Round Concentric Lay-Stranded Copper Conductors
   6. ASTM B766 Specification for Compact Round Concentric Lay-Stranded Copper Conductors

D. Insulated Cable Engineers Association (ICEA):
   1. S-96-659 (NEMA WC 71) Non-Shielded 2001 – 5 kV Cables
   2. S-96-658 Non-Shielded 0 – 2 kV Cables
3. T-33-655 Guide for Low-Smoke, Halogen-Free (LSHF) Polymeric – Cable Jackets

4. T-26-465 (NEMA WC 54) Frequency of Sampling Extruded Dielectric Cables for Test

E. Institute of Electrical and Electronics Engineers (IEEE):
   1. 383 Standard for Qualifying Class 1 E Electric Cables and Field Splices for Nuclear Power Generating Stations

F. Department of Defense, Military Specifications (MIL):
   1. MIL P-23469/4 Pin-Rivet, Grooved, Round Head; Straight Shank, Multiple Locking Grooves, Aluminum Alloys, Corrosion-Resistant and Carbon Steels

G. National Electrical Manufacturer’s Association (NEMA):
   1. NEMA WC 26 Wire and Cable Packaging
   2. NEMA WC 71 Standard for Nonshielded Cables Rated 2001-5000 Volts for Use in the Distribution of Electric Energy

H. National Fire Protection Association (NFPA):
   1. NFPA 130 Fixed Guideway Transit Systems

I. Underwriters Laboratories, Inc. (UL):
   1. UL 486A Wire connectors and Soldering Lugs for use with Copper Conductors
   2. UL 1072 Medium-Voltage Power Cables
   3. UL 1685 Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables 1992

1.04 PERFORMANCE REQUIREMENTS

A. Procure and install all Traction Power Cables from the TPSS and GBS to the Contact Rail system within the Mainline and the MSF Yard as indicated in the RFP Plans. Procure and install cables from the HECO supplied pad mounted transformer at the GBS site to the service disconnect, instrument cabinet meter panel, and the manual transfer switch within the GBS.

B. Coordinate with the Guideway Contractor and the MSF Design Build Contractor on the selection and final design of raceway sizing and routing. See Section 34 20 70 – Traction Electrification System Interface, for further requirements.

C. Coordinate with the MSF Yard Design Build Contractor for the EOS Disconnect switches cable installations routing with the raceways as specified in Section 34 20 52 – Traction Electrification System MSF Interface Requirements. Cables shall include dc positive feeder from the EOS to the Contact Rail, dc negative reference cables from the EOS to the running rail, and cables for Control, Indication, and Low Voltage Power from MSF Yard Operations & Services Building.

D. Install Contact Rail cable connection assemblies for feeder cables, jumpers, and shunts manufactured to connect the Contact Rail to the Feeders, Contact Rail to jumpers, and shunts as indicated in the RFP Plans.

E. Cables shall meet the requirements of NFPA 130.
F. Coordinate with the MSF Design Build Contractor on installing the connecting plate and connecting cables and assemblies to the Contact Rail.

G. Coordinate with Guideway Contractor to provide for the installation of the rail reference cables to the GBS.

H. The dc feeder cables shall be sized based on the maximum RMS currents with ampacity de-rating considered for the installed raceway system. DC feeder and jumper sizes shall be determined so that the temperature rating of the cables is not exceeded under normal or contingency operations of the TES.

I. Provision shall be made in the design of all dc cable terminations to prevent cable connection failures for cables terminating at the Contact Rail. Standard stranded feeder cables with a transition to extra-flexible stranding cables shall be provided for the connection to the wayside Contact Rail system as indicated in the RFP Plans.

J. DC feeders and Contact Rail jumpers shall be as indicated on the RFP Plans of the size using multiple conductors to achieve the required ampacity. Standard cable sizes shall be used to minimize installed cost.

K. For seismic requirements, see Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems.

L. For corrosion control cable requirements, see Section 26 42 01 – Corrosion Control and Cathodic Protection.

M. For grounding cable requirements, see Section 34 20 18 – Traction Electrification System MSF Grounding Requirements, and Section 34 20 19 – Traction Electrification System Grounding Requirements.

N. See Section 34 20 01 – Traction Electrification - General Requirements, for further requirements of the wind loads.

1.05 SUBMITTALS

A. General: Refer to General Conditions for Submittal Procedures, and for Shop Drawings, Product Data, and Samples requirements and procedures.

B. Submit all data, design plans, procedures and samples in accordance with Section 34 20 01 – Traction Electrification - General Requirement, submittal requirements including, but not limited to the following:

1. Shop Drawings: Submit shop drawings and cable section details for materials and cable assembly construction no later than 90 days prior to start of cable manufacturing.

2. Product Data: Submit data for power cables and associated materials.

3. Design Calculations: The following design calculations shall be submitted for approval:
   a. Calculations for all cables pulling tension
   b. Calculations for ampacity sizing of all dc Traction Power positive and negative feeder cables
   c. Calculations for ampacity sizing of all jumpers and shunt cables
   d. Calculations for the size of connection plates
4. Samples: Provide the following sample products after completion of first production lot of cables and materials:
   a. Two-foot sample of each cable size, type, and use for: 2.4 kV dc feeder cable, Contact Rail termination cable assembly, expansion joint shunt assembly, flex jumper cable assembly. Jumper connection block comprising of block with cover and lugs for 750 kcmil and 500 kcmil dc power cables.
   b. Jumper and feeder cable identification nameplates, showing type, size, embossing, and method of attachment.
   c. A complete set of 2.4 kV cable splice kit.
   d. Conduit sealing fittings/bushings for the 2.4 kV cables.
   e. Cable Connection Assemblies for jumpers, shunts, and feeders.


6. Installation, Termination, Splicing, and Testing Manuals:
   a. Provide a detailed written narrative describing the installation, terminating methods, manufacturer recommended field testing procedures, and maintenance instructions for the power cables to be furnished. Drawings, sketches, tabulation of pulling tensions, allowable bending radius descriptions, part numbers, and sources of all special tools, gauges, and handling equipment required shall be included in the manual. Manual format and contents shall conform to the requirements as outlined in the General Conditions.
   b. Draft versions of the manuals for the 2.4 kV cables shall be submitted for approval. Final versions of manuals shall be submitted 30 days after receipt of City’s comments and not less than 60 days prior to start of cable installation.
   c. The manual shall include at a minimum the following:
      1) Site storage instructions including handling, and storage requirements for short and long term.
      2) Installation equipment checklist, equipment set-up with diagram, illustrations, and sketches; and recommended lubricants for cable pulling during installation.
      3) Physical limitations of the cables relevant to cable pulling, including maximum pulling tensions, and maximum sidewall pressure.
      4) Cable pulling technique, cable training, and bending methods and limits.
      5) Cable terminations, splicing supports, and fire proofing.
      6) Instrumentation and procedures for field testing after installation and splicing. The testing procedures shall include all relevant settings and parameters such as test voltages and duration of application. The manual shall also include the fail/pass criteria for each test and any remedial measures that may be appropriate should a test fail.
      7) Cable pulling calculations and plan for each pulling segments.
      8) Provide cable schedules in accordance with the requirements of Section 34 20 01 – Traction Electrification - General Requirements.
7. Shipping, Packaging, and Marking Methods. Submit proposed procedures and methods for shipping, handling, unloading, and storing of power cables 60 days prior to first material shipment.
   a. Power cables shall be packaged for arrival at the site undamaged by handling and weather.
   b. Power cables shall be placed on non-returnable individual reels. Each reel shall contain only one continuous length of cable. Reels shall have drums with diameters of at least 12 times the outside diameter of the cable shipped thereon and shall be of substantial construction to withstand multiple handling in transit and in cable installation and outdoor storage. Each reel shall be constructed and packaged as a minimum requirement in accordance with NEMA WC 26. Submit for approval a drawing of cable reel components and construction.
   c. Reels shall have weather-resistant markings on both sides showing the purchase order number, reel number, weight, actual length, cable type, conductor type and size, number of conductors, voltage rating, and the appropriate UL labels. The numerals and letters shall be at least 1 inch high. Packing and shipping papers shall be identified with the information shown on reels. Each reel shall also be marked clearly "STAND REEL ON RIMS ONLY. DO NOT LAY ON SIDE".
   d. Power cables shall be handled so as to prevent damage to the jacket and insulation. The ends of the cable shall be hermetically sealed with heat shrinkable elastomeric cap to prevent dirt and moisture from entering the cables during storage, handling, and installation.

8. Submit cable lubricant manufacturer's certification that lubricant is compatible with cable.

9. Operations and Maintenance Manuals: Operation and Maintenance Manuals for all Traction Power equipment and materials shall conform to the General Conditions requirements.

1.06 SUPPLIER QUALIFICATIONS
   A. The Manufacturer of the power cables shall furnish a certification proving a minimum of five years business experience in the supply and manufacture of the same type and rating of power cables being supplied.
   B. The Manufacturer of power cables with Ethylene Propylene Rubber (EPR) insulation shall provide certification that the insulating and semi-conducting compounds used in the cable construction are to be a major manufacturer's proven development of their own in-house formulation and mixture, with an established quality control program for all suppliers products used in the compound make-up.

1.07 QUALITY ASSURANCE
   A. General: Refer to General Conditions for quality assurance requirements and procedures.
   B. Comply with all applicable Federal, State, and Local Laws, Regulations, and Codes including those referenced in Article 1.03.
1.08 DELIVERY, STORAGE, AND HANDLING

A. Provide Shipping in consideration of the following restrictions:
   1. Site limitations
   2. Transportation considerations

B. Provide loose components securely tied down during shipment.

C. Ship each item of material securely wrapped, packaged, and labeled for safe handling in shipment and to avoid damage.

D. Store materials and components indoors in clean, dry space with uniform temperature to avoid condensation. Protect cables from exposure to dirt, fumes, water, corrosive substances, and physical damage.

E. If stored in areas subject to weather, cover materials to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside materials.

F. Store materials in secure and dry storage facility.

1.09 WARRANTY

A. The Core Systems DBOM Contractor suppliers shall warrant that their products are free from defects. Warranty shall conform to the requirements of the General Conditions.

PART 2 – PRODUCTS

2.01 GENERAL

A. Traction power cables shall be designed to operate at a conductor temperature of 194 degrees Fahrenheit for normal operation, 266 degrees Fahrenheit under emergency conditions and 482 degrees Fahrenheit under short circuit conditions in accordance with AEIC CS8.

B. Traction power cables shall be suitable for operation in wet or dry conditions.

2.02 DC POWER CABLES

A. General

   1. Voltage Rating: DC power cables shall be rated 2,400 V dc.

   2. Markings: Cables shall be identified with continuous markings showing name of manufacturer, cable type, voltage rating, temperature rating, insulation type and thickness, and year of manufacture printed on the surface of the insulation. The cable marking shall also include the label “Property of the City”. The identification shall be durable to the extent that it will remain legible for the life of the cable under normal conditions of operation.

   3. Application: Use for dc power cables shall be as follows:

      a. Mainline Contact Rail positive and negative return feeder cables: Positive feeder cables connect the dc feeder circuit breakers in the mainline traction substations and gap breaker stations to the Contact Rail system, positive connection blocks and the negative feeder cables connect the rectifier negative bus in the traction substations to the negative connection block to the running rails.
b. MSF Contact Rail positive and negative return feeder cables: Positive feeder cables connect the dc feeder circuit breakers in the yard traction substation to the Contact Rail system Positive connection block and to the EOS. The negative feeder cables connect the rectifier negative bus in the yard traction substation to the Negative connection block at the running rails.

c. Contact Rail jumper cables: Used to connect adjacent sections of Contact Rail. For MSF area via connection blocks as indicated in RFP Plans.

d. Contact Rail expansion joint shunt cables: Used as jumper across Contact Rail expansion joints.

e. Contact Rail termination cables: Connect the Positive block at which the feeder or jumper cables are terminated to the Contact Rail.

f. Running rail termination cables: Connect the Negative block at which the returns are terminated to the running rail.

g. Running rail cross bonding cables: Connect between all four running rails.

h. Control power cables: Used in control circuits exposed to the 1,000 V dc potential, such as connections of load-measuring resistors and contactors, wiring on the isolation transducers, and connection of the load measuring circuit in gap breaker stations to the running rail.

B. Contact Rail Positive Feeder Cables, Negative Return Feeder Cables and Rail cross bonding cables: The cables shall be non-shielded, jacketed, EPR insulation suitable for installation in metal wireways, cable trays, metallic and non-metallic conduits, and underground ducts. The cables shall be operated between 750 to 1,000 V dc with transient over-voltages of up to 3,000 Vdc. The cables shall be subjected to a 720 Hz ripple voltage with a magnitude of approximately 100V peak-to-trough superimposed on the average. The cables shall be manufactured and tested in accordance with ICEA S-96-659 (NEMA WC 71), UL 1072, and ASTM B8.

1. Conductor: Conductor shall be 750 kcmil annealed uncoated copper, concentric, round, Class B stranding, conforming to ASTM B496.

2. Insulation: The EPR Insulation compound shall meet or exceed the electrical and physical characteristics per ICEA S-96-659. The cable shall have a 3130-mil average insulation thickness. The minimum thickness at any point shall not be less than 90 percent of the average insulation thickness.

3. Jacket: The jacket shall be cross linked polyolefin, zero lead, low smoke, zero halogen, flame retardant, and ultraviolet/sunlight resistant. The jacket shall conform to the mechanical properties in accordance with ICEA S-96-659/NEMA WC 71 and ICEA T-33-655. Average jacket thickness shall be 125 mils, and the minimum thickness at any point shall not be less than 80 percent of the average.

4. Flame Test: The finished cable shall pass the flame propagation test in accordance with UL 1072 and IEEE standard 383, Article 2.5.

C. Contact Rail Termination Cables, Contact Rail Jumper, and Expansion Joint Shunt Cables: The cables shall be manufactured and tested in accordance with the requirements of NEMA WC 71 (ICEA S-96-659) and UL 1072, as pertinent to non-shielded single-conductor power cable. The cables shall conform to the following requirements:

1. Conductor Sizes: Contact Rail termination cables from Positive Connection block to Contact Rail, Contact Rail jumper and expansion joint shunt cables, Negative
return termination cables from Negative Connection block to running rail shall be 500 kcmil copper.

2. Stranding: Class H rope lay stranding in accordance with the requirements of ASTM B173. They shall have a minimum strand quantity of 427 strands.

3. Insulation: Insulation shall be EPR type, same as specified for the feeder cables. It shall be rated for 2,400 volts minimum, with thickness of 140 mils.

4. Jacket: Jacket shall be made of chlorosulfated polyethylene (CSPE) ultraviolet/sunlight resistant, conforming to NEMA WC 71 (ICEA-S-96-659), ICEA T-33-655 and UL 1072 and IEEE standard 383, Article 2.5.

5. Construction: The Contact Rail termination cables shall be of the extra flexible type constructions. Cables shall be furnished with factory-assembled lugs on both ends. They shall be provided with preassembled right angle terminal lug on one end. Determine required lengths of the Contact Rail shunt cables. The cables provided shall have the capability of being trained and without undue stress on the connecting lugs to meet the required bending radius for connecting to the Contact Rail terminating points.

6. Flame Test: The assembled cable shall be certified as passing the flame test specified in UL 1072 and IEEE 383 standard, Article 2.5.

D. Cable Connection Assemblies: Cable connection assemblies shall be furnished for termination of Contact Rail termination and shunt cables.

1. Contact Rail Termination Cable Connection Assembly.
   a. Contact Rail connection plate shall be aluminum ANSI/ASC H35.1-6101-T6 alloy, dimensioned and drilled as indicated on the RFP Plans.
   b. Lugs and Welding Molds: One end of flexible jumper cable shall be pre-assembled with right angle lug. Tinned copper lugs with two-hole NEMA type configuration and welding molds shall be the product of a standard manufacturer of exothermic welding materials. Welding shall be performed in strict conformance with the manufacturer's printed recommended procedures and instructions. The welding process shall not damage the tin coating on either surface of the outstanding leg of the lug.
   c. Feeder and Jumper cable connection blocks shall be designed to join 500 kcmil stranded cables to 750 kcmil stranded cables. Cable adapter shall be of one-piece construction. Lugs for 500 kcmil and 750 kcmil cables shall be included with connection block. Connection block and cable lugs shall be as indicated on the RFP Plans.
   d. Pin bolts for attaching connection plate to rail shall meet MIL-P-23469/4 requirements and in accordance with ANSI/ASC H35.1 standards. See Section 34 24 10 – Contact Rail System, for further requirements.
   e. Fasteners for connection of cable to Contact Rail connection plate: Bolts shall be 1/2 inch diameter, ASTM A325, Type 1, cadmium plated in accordance with ASTM B766. Locknuts and Washers shall be ASTM A325, Type 1, cadmium plated in accordance with ASTM B766, size to fit bolts.

2. Contact Rail Shunt Cable Connection Assembly: The assembly shall comply with the requirements specified for Contact Rail termination cable connection assemblies, except as follows:
a. Connection plate shall be aluminum 6061-T6, dimensioned and drilled as required.
b. The two ends of the shunt cable shall be pre-assembled with right angle lugs.
c. Shunt cable trough raceway, 6-inch fiberglass conduit, shall be provided in lengths as required.
d. See RFP Plans for cable connection quantities.

E. DC Power Cable Accessories:

1. Conduit Sealing Fittings/Bushings: After dc cable installation, conduits shall be sealed with bushings at each end. Bushings shall consist of slotted PVC coated steel discs, neoprene sealing ring, and stainless steel socket head cap screws and washers. The complete bushing assembly shall be provided with the appropriate number of holes to plug/seal the stub-ups while accommodating the size and number of cables that emerge from the conduit. Spare conduits shall be sealed with blank bushings without holes.

2. Terminal Lugs:
   a. Provide compression type terminal lugs with two-hole NEMA type configuration for termination of the cables at the switchgear and at the impedance bonds on the tracks.
   b. Load measuring cables shall be terminated using two-hole NEMA lugs on the dc switchgear side, and 3/8 inch plug terminals for bonding at the running rail side.

2.03 **600 VOLT SINGLE CONDUCTOR CABLE**

A. General: Power, Control, and Indication Cables for the EOS dc Disconnect Switch shall comply with the following:

1. Conductor Material: ICEA stranded or solid copper meeting requirements of ASTM B3, soft drawn. Conductor Type: Unless specified otherwise, conductor types shall be as follows:
   b. Size 10 AWG and Larger: Class B stranded.
   c. Size 14 AWG to Size 1/0 AWG: Type THHN or THWN, polyvinyl chloride (PVC) thermoplastic insulated in accordance with NEMA WC70. Cable shall be jacketed with clear polyamide nylon over the insulation.
   d. Size 2/0 AWG and Larger: Type RHH, ethylene-propylene-rubber-insulated in accordance with ICEA S-95-658 / NEMA WC70.

2. Temperature Rating: Temperature ratings of all cables shall be not less than 167 degrees Fahrenheit.

3. Insulation Rating: 600 V.

2.04 **MULTICONDUCTOR CABLE**

A. General: Power, Control, and Indication Cables for the EOS dc Disconnect Switch shall comply with the following:

1. Provide multiple conductor cable conforming to NEMA WC70, with the following requirements:
   a. Number of Insulated Conductors: As required.
b. Provide multiple conductor cable for all power applications for sizes up to 4/0 AWG, as required.

c. Insulation: As specified above for single conductor cable.

d. Overall Covering: Cable shall be jacketed over the insulation.

e. Multiple conductors for control wire shall be a minimum of 14 AWG stranded copper.

f. Insulation Rating: 600 V.

2. Assemble multi conductor cable with individual or twisted pairs of insulated Conductors into a tight cylindrical form using fillers that are compatible with other materials in the cable. The jacket shall fit tightly to form a firm assembly.

2.05 MISCELLANEOUS MATERIALS

A. Fireproofing Materials: Fireproofing materials shall be suitable for the voltage ratings specified for cables. The fireproofing tape shall consist of a flexible, conformable fabric having one side coated with a flame retardant, flexible, polymeric coating or a chlorinated elastomer not less than 0.050-inch thick or both, and shall weigh not less than 2.5 pounds per square yard. The tape shall be noncorrosive to cable sheath, shall be self-extinguishing, and shall not support combustion. The tape shall not deteriorate when subjected to oil, water, gases, salt water, sewage, and fungus.

B. Tie Wrap: Ultraviolet resistant nylon tie wrap, in sizes as required, with no metal parts shall be provided to tie feeder cables to support structures, to bundle the power cables, and where required for other uses.

C. Cable Lubricants: Provide cable lubricants as required. No abrasive or corrosive cable lubricant will be used.

D. Cable Identification Tags: Non-metallic circular discs with two holes. System voltage, cable size, and feeder identification shall be stamped or embossed on each tag in characters of 1/4-inch minimum height. These ID tags shall be used on both ends of each traction power cable.

E. End Cap for Cables: End caps for cables shall be flame retardant heat shrinkable manufactured by Raychem, Inc., or equal. End caps shall be used for temporary sealing of cable ends.

F. Pin Bolts and Collars: Provide pin bolts and collars in accordance with Section 34 24 10 – Contact Rail System.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Cable Connector Assemblies:

1. Qualifications for performing compression connections.

a. Prior to installation, have prepared, under the direction of each foreman who will supervise a crew performing compression connections, two compression assemblies. The test compression assemblies shall be made using the methods and equipment the Contractor proposes to use for the installation. The electrical resistance of the completed connection, when measured between the end of cable and the connector tongue, shall not be greater than the resistance of an equivalent length of uncut cable.
b. The test connections shall then be subjected to a sustained tension of 5,000 psi for three hours. At the end of three hours, there shall be no slipping of the cable in the connector, deforming or loosening of the connection or increase in the electrical resistance beyond that specified.

c. The test connections shall then be heated to 464 degrees Fahrenheit by passing an electric current through the connection. After the temperature equalizes at 464 degrees Fahrenheit, the connection shall be cooled to 75.2 degrees Fahrenheit. A heating phase and a cooling phase shall constitute one cycle. The test connections shall undergo 100 cycles without increasing the resistance beyond that specified. Should any sample fail to meet the specified test requirements, the qualification of the foreman and the equipment shall be disapproved. When a crew performing connections has a change in foreman, the new foreman and the equipment shall be qualified as specified.

2. Installation of compression connectors: Compression connectors shall be attached to the cable with the manufacturer’s recommended tooling. When bolting tongues together, a lockwasher shall be installed under the head of each bolt and under each nut. All bolted connections shall be tightened with torque wrenches to a uniform torque of 450 inch-pounds or as required in accordance with the manufacturer’s instructions.

B. Terminal Lugs:

1. Testing of terminal lugs for composite Contact Rail: Terminal lugs for composite Contact Rail shall be tested as specified for cable connector assembly compression connections.

2. Installation of terminal lugs for composite Contact Rail: Cable connections to the composite Contact Rail shall be one-hole, tin-plated, copper compression connectors. Prior to assembly of the terminal lugs to the composite Contact Rail, mating surfaces shall receive a liberal coating of oxide-inhibiting paste, NO-OX-ID, Dearborn Chemical, or equal. The oxide-inhibiting paste shall also be applied to all interfaces of the compression fasteners. The methods and equipment used to fasten the terminal lugs to the composite Contact Rail shall be as recommended by the manufacturer of the rail. Compression fasteners bent or improperly installed shall be replaced. Compression fasteners shall be installed in existing compression fastener holes used to hold the aluminum extrusion in place. Existing steel compression fasteners shall be removed and new fasteners installed to hold the terminal lugs.

C. Cable Installation:

1. Cables shall be installed in raceways as indicated in the RFP Plans.

2. Cable installation shall be in accordance with the recommended procedures by the cable manufacturers on cable installation, cable pulling, and sidewall pressure calculations and methods.

3. Cable Pulling:
   a. Manholes splice and pull boxes, and conduits shall be thoroughly cleaned, dried, and free from debris prior to cable pulling. Pull wire brush, swab, and mandrel through conduit in a manner that will remove extraneous matter.

   b. Install pulleys on pulling irons where provided, otherwise temporary blocking and pulleys shall be installed and confirmed.
c. Cables shall be pulled in the direction that exerts the least tension on the cables and shall be pulled in only one direction.
d. Pull cable directly into raceway from coils or reels. Multiple cables in the same conduit/duct shall be pulled at the same time.
e. Do not install cable that has been laid on dirt. Do not pull cable with its end open.
f. Maintain rubber tape on cable ends.
g. Use cable lubricants where necessary.
h. If cable has been pulled by pulling grips, remove damaged cable ends as soon as cable has been completely pulled.
i. Seal ends of installed cable with heat shrinkable end caps to prevent entry of moisture.
j. Identify ends of cable before making connections or terminations.
k. Terminate each end of conduit with sealing bushing. Ensure that sealing bushing holds cable against movement in both directions and makes a watertight seal.
l. Tie wrap power cables after installation.

4. Pulling Equipment and Pulling Tension: Provide suitable pulling equipment on hand that is in good working order. A dynamometer shall be used to measure the pulling tensions. Values obtained shall be recorded and incorporated into the Cable Test Report. The cable manufacturer’s recommended maximum pulling tension and sidewall pressure values shall not be exceeded during cable pulling.

5. Cable Splices: DC Traction Power positive and negative feeder cables shall have no splices unless approved by the City. Where deemed necessary, splices shall be suitable for continuous immersion in water and shall only be made in splice boxes or manholes. The splices shall be installed in accordance with the splice kit manufacturer’s recommended installation procedures.

6. Cable Supports:
   a. Cables shall be routed and supported in trenches, pullboxes, manholes, and switchgear cubicles, as indicated.
   b. As a minimum, cables in manholes shall be supported at 4-foot maximum intervals with support cradles, saddles, or cable trays.
   c. Cables in concrete trenches under the substations and gap breaker stations shall be installed and supported by fiberglass cable trays.
   d. Cables entering the top of switchgear equipment in substations or gap breaker stations shall be supported by cable trays or conduits.
   e. Cables entering the switchgear cubicles from the bottom shall be supported by cable support terminators or with basket-type cable grips of the type that utilizes support rings. Cables entering 1000V dc switchgear cubicles shall be supported as described in Section 34 20 25 – DC Switchgear.

7. Cabling in Cable Tray: Only cable UL-approved for use in cable tray may be used for this application.
   a. Cable shall be placed in cable tray by hand, not pulled, except where pulling calculations and an installation method has been approved as permitted by other parts of herein.
b. The cable tray shall be sized for one layer of cables. The cables shall be run parallel to each other, without crossing, except where entering and exiting the tray. Cables shall be securely fastened every 18 inches or less using nylon wire ties.

8. Cabling in Manholes and Pull Boxes:
   a. Furnish and install cable racks, cleats, and supports to rack and anchor the cables in the pull boxes and manholes vaults as required in Section 34 20 51 – Traction Electrification System Interface Requirements, and Section 34 20 52 – Traction Electrification System MSF Interface Requirements, and as indicated in the RFP Plans.
   b. When installing cable, sufficient slack shall be left in each vault and pull box to allow for proper racking around the vault and pull box. Cable shall be supported and shaped into its final location on racks or hangers. Shaping shall be done as soon as cable pull has been completed, leaving 6 inches of straight cable out of raceway before shaping to racks.
   c. Unless the Contractor can demonstrate to the City the pull tensions adhere to the wire/cable manufacturer’s requirements, wire and cable shall not be pulled through manholes or pull box. Cable shall not be pulled in two directions from a vault or pull box, unless the cable vault or pull box cover opening is equal to 24 times the diameter of the cable. Establish that the cable can be installed without exceeding the cable minimum bending radius.
   d. Cables shall be trained as close to the vault or pull box walls as possible and still retain the minimum cable-bending radius. Cable racks shall be adjusted for optimum support of cables and splices. Racks shall be added as necessary so that each splice is supported by two racks, one on either end of the splice. Cables shall be securely fastened to the racks using wire ties, 1/4 inches or larger.

9. Installation of Traction Power Feeder Cable in Conduit with Power Winches:
   a. Contractor installing conductors in conduit by hand or with power winches, shall consider the size and weight of conductors, length of conduit run, and installation requirements and develop an installation plan.
   b. The cable installation plan shall be developed for each conduit run where cable is to be installed using power winches, and address the following considerations:
      1) Cable pulling calculations, including calculated maximum permissible tensions for the exact cable to be installed as required.
      2) The equipment set-up including sheave and reel diameters and installation methods, including methods to protect cable during installation.
   c. Pulling tension shall be continuously monitored for each pull, and the maximum values recorded and retained. Pulling tension shall not exceed the manufacturer's recommended values for longitudinal tensions and sidewall pressure, as determined by actual pulling calculations.
   d. Pulling shall be done at a constant velocity, and the pay-off reel shall be tended throughout the pull. Once a wire or cable pull is started, it shall proceed without stopping until completion.
   e. Bending radius during installation, including pulleys and sheaves, shall not be less than 12 times the wire or cable diameter. The cable shall be fed
straight into the duct in the pay-off vault or pull box and straight out of the duct at the pulling vault or pull box.

10. Cable Fireproofing: DC positive cables routed through substation and gap breaker station trench cable trays, manholes, pullboxes, or chases shall be fireproofed as follows:
   a. Cables shall be routed and supported in trenches, pullboxes, manholes, and switchgear cubicles as indicated in the RFP Plans.
   b. Strips of fireproofing tape approximately 1/16 inch thick by 3 inches wide shall be wrapped tightly around each cable spirally in half-lapped wrapping, or in two butt-joined wrappings with the second wrapping covering the joints in the first. For manholes and pull boxes, the tape shall be applied with the coated side toward the cable and shall extend one inch into the ducts. To prevent unraveling, the fireproofing tape shall be random wrapped the entire length of the fireproofing with pressure sensitive glass cloth tape.
   c. Spliced cables shall be fireproofed in accordance with the paragraph above, except with fireproofing extending only two feet beyond the spliced area on each end. Irregularities of the cable, such as at splices, shall be evened out with insulation putty before the tape is applied.

11. Cable Identification: Cable identification tags shall be affixed to each cable at each entry to and exit from each manhole, pullbox, trench, and switchgear assembly.

12. Cable Terminations: Terminations shall be installed using materials and methods as indicated in the RFP Plans or specified herein. Terminations shall be installed in accordance with the written instructions of the cable manufacturer and the termination kit manufacturer.

13. Electrical Connectors: Tighten electrical connectors and terminals in accordance with the manufacturer’s published torque-tightening values. Where manufacturer’s torque requirements are not indicated, tighten connectors and terminals to comply with tightening toques specified in UL 486A.

D. DC Traction Power Cables:
   1. Cables installed in the same raceway shall be of the same polarity.
   2. The minimum bending radius for dc power cables shall be 36 inches unless otherwise indicated in the RFP Plans or approved by the City.
   3. Terminate power cables with compression lugs.

E. Contact Rail Shunt Cables:
   1. Assemble shunt cable connection plates on Contact Rails using 3/4 inch aluminum pin bolts and collars.
   2. Pull in shunt cables in the protective trough per approved design shop drawings. No part of the cable shall rest on concrete, ballast, or ground.
   3. Connect/terminate each end of each cable to connection plates using 1/2 inch bolts, washers, and nuts. Bolts, washers, and nuts shall be cadmium-plated in accordance with ASTM B766.
F. Contact Rail Termination Cables:
   1. Assemble flexible jumper cable connection plates on Contact Rail using 3/4 inch aluminum pin bolts and collars.
   2. Terminate 500 kcmil flexible jumper cable at connection plates.
   3. Minimum ground clearance of flexible jumper cable shall be 2 inches.

3.02 CIRCUIT SEPARATION

A. Circuits of different voltages or systems shall be physically separated to reduce the possibility of unsafe conditions, interference, or equipment damage.

B. The following major circuit groups shall not be harnessed or bundled together, shall not run in the same conduit, manholes, handholes, and/or pullboxes, and shall be physically separated and secured in enclosures, junction boxes, or termination in equipment:
   1. Medium voltage ac circuits
   2. Dc positive feeder circuits
   3. Dc negative feeder circuits
   4. Low voltage ac circuits
   5. Low voltage dc circuits
   6. Fiber-optic cable

C. Wiring operating at potentials differing by 50 volts or more shall not be harnessed or cabled together.

D. Wiring of different potentials within equipment enclosures shall be separated, routed, and secured such that contact or effects from Electromagnetic Interference (EMI) or faults between wiring of different systems is not possible. All wiring within an enclosure shall be insulated for the highest voltage in the enclosure, unless approved otherwise.

E. Separation and/or electromagnetic shielding shall be provided between the conductors of high current switching or transient generating equipment and the wiring of semiconductor, logic, or communication circuits such that interference does not occur between circuits.

3.03 TESTING

A. General: Testing shall be performed in accordance with Section 34 20 80 – Traction Electrification Systems Testing.

B. See Technical Provision TP-02, “Verification, Testing, and Acceptance” for further requirements.

C. Adhere to the additional requirements and specifications of reference Article 1.03 herein.

END OF SECTION
PART 1 – GENERAL

1.01 SUMMARY

A. Description: The Work specified in this Section includes for the Core Systems Design–Build-Operate-Maintain (DBOM) Contractor for providing design, procurement, and installation of the equipment and materials to facilitate the installation of the Traction Electrification System (TES) dc traction power and communication exposed raceways, pull boxes, and their supports from the base of the Guideway support pier to aerial Guideway deck. Also included in the Work are provisions needed for complete installation of the TES raceways and block-outs on the aerial structure for the cross bond and negative returns cables. Coordinate the design work with the Guideway Contractor (GC) and with the Passenger Station Contractor (SC) for the Emergency Trip System/Blue Light Station (ETS/BLS) power and communications systems raceways at the station platforms as required. The Work includes but is not limited to the following:

1. Raceways for the TES dc positive feeders and negative return feeders from the base of guideway deck column pier Poly Vinyl Chloride/Galvanized Rigid Steel (PVC/GRS) stub up connection point to the expansion joint continuing to the soffit underneath the guideway. The Work includes drilling, embedding inserts, and installing Unistrut channel strut for the support system of these raceways, as indicated in the RFP Plans.

2. Raceways for the TES dc positive feeders and negative return feeders continuing along soffit to the TES pull box, with continued routing through the conduit sleeves, installed by the Guideway Contractor within the guideway deck, and continuing to the Contact Rail block cable connection points. The Work includes securing these raceways to the embedded channel strut and inserts support system, installed within the guideway infrastructure as indicated in the Guideway Contractor approved shop drawings and the RFP Plans.

3. Raceways for communications, from the base of guideway deck column pier PVC/GRS stub up connection point to the expansion joint continuing to the soffit underneath the guideway. The Work includes drilling and embedding inserts and installing channel strut for the support system of these raceways as indicated in the RFP Plans.

4. Raceways for communications continuing along soffit to the communications pull box, with continued routing to the system wide raceway. The Work includes securing these raceways to the embedded channel strut and inserts support system, installed within the guideway infrastructure as indicated in the Guideway Contractor approved shop drawings and the RFP Plans.

5. Raceways through block-outs or sleeves throughout the aerial guideway structure safety walkway for cross bond and negative return cables as indicated in the RFP Plans.

6. Raceways, as required, for the ETS/BLS mounted on the side wall of the Prefabricated Enclosure Mainline and Yard Traction Power Substation (TPSS)
and the Gap Breaker Station (GBS) to provide for the ETS/BLS power and control from within the Prefabricated Enclosure as indicated in RFP Plans.

7. Exposed raceways as required for the GBS HECO service requirements for the instrument cabinet, service disconnect switch, electric meter, and those to the GBS manual transfer switch within the GBS prefabricated enclosure.

B. Section Includes:
   1. Installation
   2. Junction and Pullboxes
   3. Conduits and Fittings
   4. Inserts
   5. Channel Strut

C. Related Sections:
   1. Section 26 05 33 – Raceway and Boxes for Electrical Systems
   2. Section 26 05 48 - Vibration and Seismic Controls for Electrical Systems
   3. Section 26 42 01 - Corrosion Control and Cathodic Protection
   4. Section 34 20 01 – Traction Electrification - General Requirements
   5. Section 34 20 18 - Traction Electrification System MSF Grounding Requirements
   6. Section 34 20 19 – Traction Electrification System Grounding Requirements
   7. Section 34 20 51 - Traction Electrification System Interface Requirements
   8. Section 34 20 52 - Traction Electrification System MSF Interface Requirements
   9. Section 34 20 70 - Traction Electrification Systems Interface

1.02 PRICE AND PAYMENT PROCEDURES
   A. General: Separate measurement or payment will not be made for the Work required under this Section. All cost in connection with Work specified herein will be considered to be included with the related item of work in the General Conditions requirements, or incidental to the Work.

1.03 CODES, STANDARDS, AND RECOMMENDED PRACTICES
   A. ASTM International (ASTM):
      2. ASTM A153 Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
5. ASTM D149  Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies


10. ASTM E84  Tunnel Test Applied to Floor Coverings

11. ASTM F512  Smooth-Wall Poly Vinyl Chloride (PVC) Conduit and Fittings for Underground Installation

B. American National Standards Institute (ANSI):

1. ANSI C80.1  American National Standard for Electrical Rigid Steel Conduit

C. Comply with State of Hawaii OSHA requirements

D. National Fire Protection Agency (NFPA):

1. NFPA 70  National Electrical Code (NEC)

E. National Electrical Manufacturers Association (NEMA):

1. NEMA FG1,  Fiberglass Cable Tray Systems

2. NEMA TC 2  Electrical Plastic Tubing (EPT) and Conduit (EPC-40 and EPC-80)

3. NEMA TC 3  PVC Fittings for Use with Rigid PVC Conduit and Tubing

4. NEMA TC 6 and 8  PVC and ABS Plastic Utilities Duct for Underground Installation

5. NEMA TC 9  Fittings for ABS and PVC Plastic Utilities Duct for Underground Installation

F. Hawaii Statutes and Code of Regulations

G. Underwriters Laboratories, Inc. (UL):

1. UL 5  Surface Metal Raceways and Fittings

2. UL 6  Rigid Metal Conduit

3. UL 50  Enclosures for Electrical Equipment

4. UL 514B  Fittings for Conduit and Outlet Boxes

5. UL 651  Schedule 40 and 80 Rigid PVC Conduit

H. The materials and devices covered in this Section shall be designed and tested in accordance with the appropriate industry standards, applicable to the respective equipment.
1.04 PERFORMANCE REQUIREMENTS

A. General: Prior to construction, coordinate and confirm the Traction Power and communication requirements for developing the final design.

B. Furnish all labor, materials, tools, and equipment to perform the following:

1. Design of the raceways associated with each TES site, as indicated in the RFP Plans. See Section 26 05 33 – Raceway and Boxes for Electrical Systems and Section 26 05 00 – Common Work Results for Electrical Systems, for further requirements.

2. Structural design calculations for inserts to support the cables and raceways.

3. Coordinate with the Guideway Contractor for the exact location of raceway riser sleeves within the guideway deck.

4. Ensure that sealant compound is applied between the raceway and the sleeves in the Guideway Deck to prevent penetration of water to the pull box below.

5. Design and provide calculations of raceways supports in accordance with Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems.

6. Coordinate the installation and support of expansion joints with the Guideway Contractor and as required by the manufacturer’s installation requirements.

7. Perform cable-pulling calculations to confirm and finalize the sizes and locations of the positive and negative dc feeders.

8. Perform cable-pulling calculations to confirm and finalize the sizes and locations of the fiber optic communications cables.

9. Conduit sleeves embedded in the guideway deck, for termination of positive and negative return feeders, shall be coordinated with the structural elements of the guideway, as well as the required cable termination points on the contact rail system (positive feeders) and the running rail (negative return feeders).

10. Conduit sleeves installed across the guideway safety walkway, as indicated in the RFP Plans, shall be coordinated with rail support pedestal breaks.

11. Provide and install cable trays for the positive and negative feeder cables indicated within the trenches at the TPSS and GBS as indicated in the RFP Plans. Provide a safety factor of 1.5 and submit calculations in accordance with the approved shop drawings.

12. Install and fasten pullbox within the aerial guideway soffit utilizing the embedded inserts as installed by the Guideway Contractor.

   a. Verify that the embedded supports within the soffit installed by the Guideway Contractor is of adequate strength to support the raceway system before installing pullbox.

13. Install raceways and within the aerial guideway soffit utilizing the embedded inserts as installed by the Guideway Contractor. Raceways include, but are not limited to, the (positive feeders) and the running rail (negative return feeders). Design raceways capable of being supported by the combined weight of supported systems and its contents.

   a. Coordinate and verify that the embedded supports within the soffit installed by the Guideway Contractor is of adequate strength from tension, shear, pullout force, and wind load to resist maximum loads either calculated or
imposed with a minimum structural safety factor of five times the applied force.

b. It is the responsibility of the Core Systems Contractor to design and verify with the City to determine the final defined approved routing and raceway sizes before installing the raceway system. The RFP Plans show minimum stacking height and location of embedded support channel placement and should not be taken as the basis for the final design of the embedded channel supports or the raceway quantity and sizes required.

c. Finalize the design of the support and adequacy of bearing the conduit load cables before pulling cables and submit to the City the adequacy of the system. If failures to the support system or cables occur during installation of the raceways and subsequent pulling of the cables, it is the Contractor’s responsibility to rectify the failures at the approval of and without cost to the City.

14. For seismic requirements, see Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems.

15. For corrosion control requirements, see Section 26 42 01 – Corrosion Control and Cathodic Protection.

16. For grounding requirements, see Section 34 20 18 – Traction Electrification System MSF Grounding Requirements and Section 34 20 19 – Traction Electrification System Grounding Requirements.

17. Ref to Section 34 20 51 – Traction Electrification System Interface Requirements, Section 34 20 52 – Traction Electrification System MSF Interface Requirements, and Section 34 20 70 – Traction Electrification System Interfaces, for further requirements.

18. See Section 34 20 01 – Traction Electrification - General Requirements, for further requirements of the wind loads.

1.05 SUBMITTALS

A. General: Refer to General Conditions for Submittal Procedures, and for Shop Drawings, Product Data, and Samples requirements and procedures.

B. Submit all data, design plans, procedures and samples in accordance with Section 34 20 01 – Traction Electrification - General Requirements, submittal requirements including, but not limited to the following:

1. Shop Drawings:
   a. Submit for approval detail drawings, plans depicting fabrication, and installation of raceways and appurtenances.
      1) Detailed drawings of divider partitions, support structures, anchors including installation instructions
   b. Identify each drawing by a number and descriptive title.
   c. Submit for approval and fully demonstrate that the Work to be performed complies with the provisions of herein.
   d. Support design calculations for the insert support elements comply with the requirements of Article 1.04 herein.
2. Manufacturer's product data:
   a. Provide a complete materials list for approval of all items proposed to be furnished and installed under this Section.
   b. Manufacturers’ specifications and installation instruction sheets.
   c. Submit Catalog cuts product data on the following items:
      1) Conduit
      2) Miscellaneous hardware and metal items for raceways
      3) Junction boxes
      4) Pullboxes
      5) Pull Rope
      6) Supports
      7) End Bells
      8) Expansion joints
   d. Provide for all specified products - Certificates of Compliance.

3. Design Submittal: See Section 34 20 01 – Traction Electrification - General Requirements, for the requirements of the Professional Engineer to prepare the RFP Plans.

4. Field Test Reports: Submit certified field test reports as indicated.

5. Operations and Maintenance Manuals: Operation and Maintenance Manuals for all Traction Power equipment and materials shall conform to the General Conditions requirements.

1.06 QUALITY ASSURANCE
   A. General: Refer to General Conditions for quality assurance requirements and procedures.
   B. Comply with all applicable Federal, State, and Local Laws, Regulations, and Codes including those referenced in Article 1.03.

1.07 DELIVERY, STORAGE, AND HANDLING
   A. Delivery: Deliver materials to worksite. Ship each item of equipment and materials securely wrapped packaged and labeled for safe handling in shipment and to avoid damage.
   B. Storage: Store equipment and materials in secure and dry storage facility and in accordance with manufacturer's recommendations.
   C. Protection: Protect materials before, during, and after installation. Protect installed work and materials of other trades. In event of damage, immediately make repairs or replacements.
   D. Worksite Conditions: During non-work hours, and at locations where installation of exposed raceway is temporarily suspended or terminated, close ends of ducts with caps or plugs fitted to prevent entry of water or debris. Use caps or plugs designed for this purpose in accordance with the requirements of the conduit manufacturer.
1.08 WARRANTY

A. The Core Systems DBOM Contractor suppliers shall warrant that their products are 
free from defects. Warranty shall conform to the requirements of the General 
Conditions.

PART 2 – PRODUCTS

2.01 RACEWAYS

A. Requirements for interior conduits, fittings, and accessories; conduit hangers; and 
inserts, outlet, junction, and pull boxes shall be in accordance with Section 26 05 33 – 
Raceway and Boxes for Electrical Systems.

2.02 CONDUIT

A. Galvanized Rigid Steel (GRS) Metallic Conduit and Accessories:

1. Provide GRS conduit, couplings, elbows, bends, sealing fittings, and nipples 
conforming to ANSI C80.1 and UL 6 with each length bearing manufacturer’s 
stamp and UL label.

2. Thread protectors installed on both ends of conduit for shipment and handling, 
with couplings packaged separately.

3. Provide GRS conduit as indicated in the RFP Plans.

4. Fittings and Accessories:
   a. Provide separable watertight hub fittings with a gasket, separate nylon 
insulated throat and a case hardened locknut conforming to UL 514B bearing 
manufacturer’s stamp and UL label.
   b. Provide bushings of nylon-insulated metallic and grounding type.
   c. Provide conduit straps, clamps, and clamp backs made of galvanized 
malleable iron.
   d. Thread protectors installed on both ends of conduit for shipment and 
handling with couplings packaged separately.

B. Conduit Expansion Fittings:

1. Fabricate expansion fittings from material similar to the type of conduit with 
which they are to be used.

2. Include a factory installed packing ring, designed to prevent the entrance of 
moisture and a pressure ring.

3. Include a grounding ring or a grounding conductor for metallic expansion 
couplings.

4. Fittings shall maintain a constant inside diameter in every position, and shall 
provide a smooth wireway for protection of wire insulation.

C. PVC Electrical Conduit and Fittings:

1. Provide heavy wall, high impact strength, rigid PVC conforming to the 
requirements of EPC-40-PVC conduit of NEMA TC 2 and fittings for EPC-40-
PVC conduit of NEMA TC 3. For underground conduits, conform to the 
requirements of NEMA TC 6 and 8 PVC Plastic Utilities Duct for Underground

2. Conduit and fittings shall be UL651 listed and shall conform to National Electrical Code for underground and exposed use.

3. Conduit and fittings shall be flammability rated as self-extinguishing and shall have the following minimum properties:
   a. Tensile strength, ASTM D638 at 78 degrees Fahrenheit: 6,000 psi
   b. Flexural strength, ASTM D790: 11,000 psi
   c. Compressive strength, ASTM D695: 8,500 psi
   d. Hardness (Durometer D), ASTM D2240: 77
   e. Water absorption, percent maximum in 24 hours at 72 degrees Fahrenheit: ASTM D570: 0.03
   f. Dielectric strength, ASTM D149: 1.1 kV/mil
   g. Thermal conductivity: 1.3 Btu/sq. ft. degree Fahrenheit/in.
   h. Pipe Stiffness, ASTM F512: 35 lb/in/in (500,000 psi modulus)

D. Bell Ends: Flared bell ends on conduits entering manholes, handholes, and pullboxes.

E. Innerduct multicell conduit for communication use shall be as a minimum of 5-inch diameter or as indicated in the RFP Plans. It shall consist of four prelubed PVC ducts with each duct having a nominal 1 inch diameter.

2.03 FIBERGLASS CABLE TRAYS

A. Fiberglass trays shall be ladder type, manufactured from fiberglass-reinforced polyester resin in compliance with NEMA FG1, with the features noted below:
   1. Dimensions: Inside usable depth shall be a minimum of 4 inches. Outside depth shall be 6 inches maximum.
   2. Fitting Radius: As required to meet the installation, as indicated in RFP Plans.
   3. Rung Spacing: Maximum 9 inches between centers.
   4. Working Load: Submit calculations in accordance with the approved shop drawings. Provide a safety factor of 1.5.
   5. Fabrication: Straight section shall consist of rungs located between channel-shaped side rails.
   6. Flame Spread Index: 25 maximum in accordance with ASTM E84.
   7. Smoke Density: 450 maximum in accordance with ASTM E84.

2.04 JUNCTION AND PULLBOXES

A. Provide junction boxes, and pull boxes conforming to NEC, Article 70.

B. Electrical boxes shall conform to UL 50 and UL 514B.

C. Provide electrical boxes of the material, finish, type, and size indicated for the location, kind of service, and function.

D. Boxes shall have mounting holes.

E. Provide boxes complete with accessible flat covers designed for quick removal.
F. Pull boxes shall be NEMA Type 4 fiberglass with gasketed fiberglass covers boxes for surface mounting.

G. Covers shall be of same thickness as boxes and shall be secured in position by means of stainless steel machine screws. Arrange covers to be readily and conveniently removed.

H. Provide brackets, supports, hangers, fittings, and other installation accessories as required.

I. Provide neoprene gaskets 1/8-inch thick for boxes subjected to weather.

2.05 POST INSTALLED INSERTS

A. Post Installed inserts for embedding in guideway concrete column pier:
   1. Steel, galvanized after fabrication, in accordance with ASTM A153.
   2. Design for a maximum loading, as indicated in Article 1.04 herein.
   3. Knockout openings to accommodate either square or rectangular nuts.

2.06 CHANNEL STRUT

A. All channel members shall be fabricated from structural grade steel conforming to ASTM A1011 SS Grade 33.

B. All fittings shall be fabricated from steel that conforms to and meets the physical requirements of ASTM A1011 SS Grade 33.

C. Finishes: Channel strut system components shall be Hot-dipped Galvanized in accordance with the requirements of ASTM A123, and tested to ASTM B117 requirements.
   1. Zinc coated after all manufacturing operations are complete
   2. Zinc coating thickness shall be G65 at minimum thickness of 2.6 mils equal to 1.50 oz. /sq. ft. surface area

D. Manufactured by Unistrut Type HG or approved equal.

2.07 INITIAL PROVISIONING

A. Provide an itemized list of parts with quantities, order preference, and price that the Contractor recommends for 2 years of operation before restocking. The reference number for each item shall include the Contractor’s and the original manufacturer’s part numbers. See Technical Provision TP-03, “O&M Performance Requirements” for further requirements.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install electrical raceway materials, equipment, and accessories in location as indicated, rigid and secure, plumb and level, and in alignment with related and adjoining work to provide a complete and operable system. Do not weld electrical materials for attachment or support, except as otherwise specified in Section 34 20 19 – Traction Electrification System Grounding Requirements, for electrical continuity bonding and grounding. Installation shall comply with State of Hawaii OSHA, statutes and code of regulations.
B. Provide anchor bolts and anchorage items as required, and field check to ensure proper alignment and location. Provide templates, layout drawings, and supervision at the worksite to ensure correct placing of anchorage items in concrete. Coordinate with the Guideway Contractors where embedded anchors are to be installed to support raceways and pull boxes for correctness of location and detail before concrete is to be placed.

C. Install supporting members, fastenings, framing, hangers, bracing, brackets, straps, bolts, and angles as required to set and connect the work rigidly.

D. Control erection tolerance requirements to not impair the strength, safety, serviceability, or appearance of the installations. Determine exact locations of conduit. Route conduit parallel to Guideway structure lines unless otherwise indicated.

E. The trade size, type, and general routing and location of conduits, raceways, and boxes shall be as indicated in the RFP Plans and specified herein.

F. Install exposed conduit to avoid conflicts with other work.

G. Use of powder-actuated or explosive fasteners is prohibited.

H. Furnish accessory parts to form a complete assembly, furnish core drills, hole saws, afterset inserts, and insert extensions as required for normal installation.

I. All metallic raceways including boxes shall be electrically continuous and connected to ground by bonding to the grounding system.

3.02 JUNCTION AND PULL BOXES

A. Mount pullboxes to prevent moisture from entering or accumulating within the boxes. Mount pullboxes under the Guideway and as indicated on the RFP Plans. Do not use conduits entering the box as a support for the box.

1. Install covers so that they are readily accessible after completion of the installation.

2. Provide sealants to prevent water penetration.

3.03 CONDUIT AND FITTINGS

A. Electrical Conduit - Installation Requirements:

1. Install conduit in accordance with the NEC and as indicated. Prevent materials from entering and obstructing the conduit, and pull boxes.

2. Unless otherwise indicated, make conduit bends in accordance with the NEC. Where more bends are required in a particular run, install pullboxes as required to facilitate pulling conductors even if not indicated.

3. Provide and install metallic numbering tags on both ends of all conduits. Tags shall indicate the conduit identification number.

4. Contractor’s final design shall properly support and anchor conduit to maintain correct location and spacing, to prevent movement through suitable metal supports. Provide expansion fittings in conduit runs to compensate for thermal expansion.

5. Metallic conduits shall be electrically and mechanically continuous and connected to ground by bonding to the grounding system.
6. Apply conductive compound to the threads of threaded rigid conduit joints. Do not use compounds containing lead. Terminate the conduit in appropriate boxes at junction points.

7. When field cutting of conduit is required, thread and ream the conduit to remove rough edges. Where a conduit enters a box or other fitting, provide a bushing to protect the wire from abrasion. Provide insulation type bushings and double locknuts on ends of rigid conduits terminating at boxes and enclosures.

8. Space conduits installed against concrete surfaces 1/4 inch away from the surface by clamp backs or other approved means.

9. Support individual horizontal conduits larger than 1-1/2 inches in diameter by individual hangers and forged steel conduit strap for vertical runs. Utilize insets as needed for the conduit support.

10. Space supports not over ten feet on centers for vertical conduits spanning open areas. Securely anchor conduit at each end.

11. All outside installations shall be GRS as indicated on the RFP Plans.

12. Seal conduits with watertight duct sealing system.

B. Pull Cords:
   1. Provide 1/4 inch polypropylene nylon pull cords of tensile strength not less than 240 pounds in each conduit.
   2. Splices in pull cords will not be permitted.
   3. Leave 10 feet of slack length at each end of pull cords.
   4. All pull cords will have labels for conduit number, start location, finish location and linear footage at each end.
   5. All pull cords will have bell covers at each end.

3.04 INSERTS

A. Post installed drilled type:
   1. Install with the insert face flush with the finished concrete surface, firmly embedded, with no evidence of movement.
   2. Holes shall be drilled by methods that will not shatter or damage the concrete adjacent to the holes. If reinforcement is encountered during drilling, the City shall be notified before the specified depth is attained.
   3. Unless the City approves in writing, coring through the reinforcement, the hole will be rejected and a new hole, in which reinforcement is not encountered, shall be drilled adjacent to the rejected hole to the depth recommended by the manufacturer.
   4. Drilled holes shall be cleaned in conformance with the manufacturer’s instructions and shall be dry at the time of placing the epoxy cartridge bonding material and the insert.
   5. The bonding material shall be a 2-component epoxy system contained in a cartridge having two separate chambers and shall be inserted into the hole using a dispensing gun and replaceable mixing nozzle approved by the manufacturer.
6. Unless other specified, the depth of hole and the installation procedure shall be as recommended by the manufacturer.

7. Immediately after inserting the insert into the epoxy, the insert shall be supported as necessary to prevent movement during curing and shall remain undisturbed until the epoxy has cured a minimum time as specified by the manufacturer.

8. Inserts that are improperly bonded, as determined by the City, will be rejected.

9. Adjacent new holes shall be drilled, and new inserts shall be placed and securely bonded to the concrete. All work necessary to correct improperly bonded dowels shall be performed at the Contractor’s expense.

### 3.05 CHANNEL STRUT

A. Set strut system components into final position true to line, level, and plumb in accordance with approved drawings.

B. Anchor material firmly in place, and tighten all connections to their recommended torques.

### 3.06 TESTING

A. Provide field testing reports of the installed support anchors and inserts in accordance with Article 1.05 herein.

END OF SECTION
SECTION 34 20 70  
TRACTION ELECTRIFICATION SYSTEM INTERFACES

PART 1 – GENERAL

1.01 SUMMARY

A. Description: The Work included in this Section specifies the description and the general requirements for the various interfaces between Contractors and defines the division of responsibilities at each of the Traction Electrification System (TES) interfaces.

1. The Core Systems Design–Build-Operate-Maintain (DBOM) Contractor (CSC) shall be responsible for the design and development of the interface between furnished materials, equipment and the installation by the Guideway Contractor (GC), MSF Design Build Contractor (MSFDBC), and the Passenger Station Contractor (SC).

2. Interface between Contractors shall be through the City. The CSC shall cooperate with the City and shall respond appropriately within 15 calendar days following receipt of any request on behalf of any Contractors. The Contractors shall be required to respond in a similar manner to requests on behalf of the City.

B. Related Sections:
1. Section 26 42 01 – Corrosion Control Fiber Optic Cabling Network
2. Section 27 13 01 – Fiber Optic Cabling Network
3. Section 27 30 01 – Telephone Systems
4. Section 27 60 00 – SCADA System
5. Section 33 70 00 – Electrical Utilities
6. Section 34 20 01 – Traction Electrification - General Requirements
7. Section 34 20 05 – Prefabricated Enclosures
8. Section 34 20 10 – AC Switchgear
9. Section 34 20 18 – Traction Electrification System MSF Grounding Requirements
10. Section 34 20 19 – Traction Electrification System Grounding Requirements
11. Section 34 20 25 – DC Switchgear
12. Section 34 20 30 – Negative Grounding Device
13. Section 34 20 35 – Control and Annunciation System
14. Section 34 20 50 – Miscellaneous Materials and Devices
15. Section 34 20 51 – Traction Electrification System Interfaces
16. Section 34 20 52 – Traction Electrification System MSF Interfaces
17. Section 34 20 55 – Wayside DC Disconnect Switches
18. Section 34 20 60 – Traction Power Cables
19. Section 34 20 65 – Traction Power Raceways
20. Section 34 20 80 – Traction Electrification System Testing
21. Section 34 24 10 – Contact Rail System
22. Section 34 24 11 – Traction Electrification System Contact Rail Requirements
23. Section 34 44 00 – Train Control System

1.02 PRICE AND PAYMENT PROCEDURES

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

1.03 PERFORMANCE REQUIREMENTS

A. The Contractors described herein shall provide for the interfacing of the TES Facilities and Structures such as the Mainline Aerial Guideway Civil Works, Traction Power Substations (TPSS) and Gap Breaker Station (GBS), Passenger Station, Maintenance and Storage Facilities (MSF), with the various systems located at these areas including Communication System, Train Control System, Contact Rail System, Track Running Rails, TES Power Feeders, and the Hawaiian Electric Company (HECO) Utility interface points. The Contractor interfaces are as described herein, but are not limited to the following:

B. Mainline Civil Works Aerial Guideway:

1. Fiber Optic Communication Network (FOCN) Systems Interface to TPSS and GBS Facilities for raceways and cables to Aerial Guideway System Wide raceways for the Emergency Trip System/Blue Light Station (ETS/BLS), Transfer Trip (TT) and E-Telephone systems.
   a. Specification: CSC defines the equipment location, mounting requirements, conduit sizes, and detailed conduit routing, end locations, and specifies support elements for exposed raceway and underground ductbanks at TPSS and GBS Traction Power system sites. The CSC specifies the cable sizes, quantities, and types.
   b. Design:
      1) CSC designs conduits from base of Aerial Guideway column pier to pullbox under soffit and to system wide raceway.
      2) CSC designs and develops size and type of cables, end locations and detailed routing, and the support elements of the raceways on the Aerial Guideway column pier.
      3) GC incorporates CSC system requirements and develops designs for the location, mounting requirements, conduit size requirements, end locations, detailed conduit routing of underground ductbanks, handholes, and manholes to the TPSS and GBS Traction Power system sites. The GC designs only the support elements for exposed raceways in the Aerial Guideway soffit indicated in the RFP Plans.
      4) CSC designs the conduits from base of column pier to the communications pull box and to the knockouts in the Aerial Guideway deck.
   c. Review: CSC reviews and corrects designs with respect to the system requirements for the mounting requirements, conduit size requirements, end
locations, detailed conduit routing and support elements for the exposed raceway, pullboxes at the Aerial Guideway structure and underground ductbanks, handholes locations at the TPSS and GBS Traction Power system sites.

d. Procurement and Installation:

1) GC implements raceway design furnishes and installs support elements within the Aerial Guideway soffit for exposed raceway and provides underground ductbanks including hand holes at TPSS and GBS Traction Power system sites, as specified in Section 34 20 51 – Traction Electrification System Interface Requirements.

2) CSC is responsible to furnish and install all conduits from base of Aerial Guideway column pier to the communication pull box as indicated in the RFP Plans. CSC is responsible to install the support elements within Aerial Guideway column pier for support of these conduits. CSC is responsible to furnish and install all cables and seal the ends of conduits at TPSS and GBS and at system wide ductbank as specified in Section 34 20 65 – Traction Power Raceways and Section 34 20 60 – Traction Power Cables.

e. Completion of Work: CSC is responsible for the correct operation of the civil-to-systems and system to system interfaces and is required to fix and provide all necessary changes in design and materials, including all civil rework for any misdefined interfaces at its expense.

2. Train Control System Impedance Bonds, where provided, Interface to TES Feeder Cables and raceways from TPSS and GBS:

a. Specification: CSC defines the cable sizes, quantities and types, detailed cable routing location, mounting requirements, exposed raceway conduit sizes, and detailed conduit routing, end locations, block out sleeve openings in walkway, support elements required in Aerial Guideway for exposed raceway.

b. Design:

1) GC incorporates CSC system requirements and develops designs for the support elements required in Aerial Guideway deck and the block-out sleeve openings in walkway, for the exposed raceways for the Train Control interface.

2) CSC develops design of cables system and end locations and detailed routing to the impedance bonds, where provided.

c. Review: CSC reviews and corrects designs with respect to the system requirements the support elements required in Aerial Guideway Deck for the exposed raceways.

d. Procurement and Installation:

1) GC implements raceway design furnishes and installs support elements in Aerial Guideway Deck for exposed raceway and the block-out sleeve openings in walkway as specified in Section 34 20 51 – Traction Electrification System Interface Requirements.

2) CSC is responsible to furnish and install all exposed conduits, and to furnish and install all cables and seal the ends of conduits within the Aerial Guideway Deck as specified in Section 34 20 65 – Traction Power Raceways.
e. Completion of Work: CSC is responsible for the correct operation of the civil-to-systems and system to system interfaces and is required to fix and provide all necessary changes in design and materials, including all civil rework for any misdefined interfaces at its expense.

3. Contact Rail System and track running rail Interface with TES Feeder Cables, connection blocks, Return Cables, Cross Bonds, Jumpers, shunt cables, and feeder connection plates.
   a. Specification:
      1) GC defines contact rail system layouts, locations of expansion joints, insulator supports, and end approach assemblies.
      2) CSC defines the cable sizes, for the cross bonding, flexible jumpers, and flexible shunt cables, cable connection plates and connection blocks, quantities and types, and connection to track running rails. CSC shall also provide the detailed cable routing location of exposed raceway, conduit sizes, and detailed conduit routing in respect to the GC defined Contact Rail system installation layout requirements and the vertical sleeves in Aerial Guideway deck as indicated in the RFP Plans.
   b. Design:
      1) GC incorporates CSC system requirements and designs the Contact Rail system in accordance with the CSC defined requirements for the cable sizes, quantities and types, detailed cable routing location, mounting requirements, exposed raceway conduit sizes, detailed conduit routing, and the support elements within the Aerial Guideway deck for the exposed raceways.
      2) CSC designs the cable sizes, quantities and types, detailed cable routing, location of exposed raceway, conduit sizes, and detailed conduit routing in respect to the GC designed Contact Rail system layout, the connections to track running rails, locations of the connection blocks and contact rail feeder, jumper, and shunt connection plates.
   c. Review: CSC reviews and corrects GC designs with respect to the Contact Rail system layout requirements, cable connections to contact rail and track running rails, the raceway systems, and the support elements required for the exposed raceways in Aerial Guideway Deck.
   d. Procurement and Installation:
      1) GC implements Contact Rail design, furnishes, and installs the Contact Rail system and support anchor placements sleeves in Aerial Guideway Deck. See Section 34 24 11 – Traction Electrification System Contact Rail Requirements and Section 34 20 51 – Traction Electrification System Interface Requirements.
      2) CSC is responsible to furnish and install all exposed conduits and cables, and seal ends of conduits within the Aerial Guideway deck for the cross bonding, jumper and shunt cables. CSC is also responsible to install connection blocks, connection plates, and cables to the Contact Rails and Running Rails, as indicated in the RFP Plans. See Section 34 20 60 – Traction Power Cables and Section 34 20 65 – Traction Power Raceways.
   e. Completion of Work: CSC is responsible for the correct operation of the civil-to-systems and system to system interfaces and is required to fix and
provide all necessary changes in design, materials, including all civil rework for any misdefined interfaces at its expense.

4. Aerial Guideway Deck Interface of feeder cables from connection block assemblies through sleeves in Aerial Guideway Deck to pullbox under soffit and continuing to base of Aerial Guideway column pier through the exposed raceways as indicated in the RFP Plans.
   
a. Specification: CSC defines the cable sizes, quantities and types, detailed cable routing, location of exposed raceway conduit sizes, detailed conduit routing, and coordinates with the defined GC sleeves in Aerial Guideway Deck to the feeder and return pullboxes under Aerial Guideway soffit and continuing from pull box under soffit to base of column pier. CSC defines support elements requirements in Aerial Guideway soffit for the raceway support of the conduits and pullboxes.
   
b. Design:
      1) CSC designs the cable sizes, quantities and types, detailed cable routing, through the sleeves in the Aerial Guideway deck, the support elements in the Aerial Guideway column pier, location of exposed raceway conduit sizes, and detailed conduit routing in accordance with the RFP Plans.
      2) GC incorporates CSC system requirements and coordinates the designs for the support elements in soffit, with the Aerial Guideway deck sleeve penetrations.
   
c. Review: CSC reviews and corrects designs with respect to the raceway systems and the support elements required in Aerial Guideway soffit for the exposed raceways.
   
d. Procurement and Installation:
      1) GC implements raceway design support and furnishes and installs the support elements for the exposed raceway under the soffit only. See Section 34 20 51 – Traction Electrification System Interface Requirements.
      2) CSC is responsible to furnish and install the pull boxes, the exposed conduits to base of column pier. The CSC installs supports on the Aerial Guideway column pier and all exposed conduits, furnishes and installs cables and seal ends of conduits within the Aerial Guideway deck sleeves, at pullboxes and exposed raceways on the soffit and the column pier. See Sections 34 20 65 – Traction Power Raceways and Section 34 20 60 – Traction Power Cables.
   
e. Completion of Work: CSC is responsible for the correct operation of the civil-to-systems and system to system interfaces and is required to fix and provide all necessary changes in design, materials, including all civil rework for any misdefined interfaces at its expense.

5. Interface of TPSS TES Feeder Cables and raceways from base of column pier to underground ductbanks into cable trenches in TPSS and GBS foundations. For GBS only the rail reference circuit raceways for the Negative Grounding Device (NGD).
   
a. Specification: CSC defines the cable sizes, quantities and types, detailed cable routing location of manholes, detailed conduit routing, underground
ductbanks, cable trenches, mounting requirements of cable trays for the Feeders, and the rail reference circuit for NGD at the GBS.

b. Design:
   1) GC incorporates CSC system requirements and designs for the cable sizes, quantities and types, detailed cable routing location of exposed raceway, detailed conduit routing, conduit sizes, manholes, handholes, ductbanks, cable trenches, and the mounting requirements for the cable trays.
   2) CSC designs the cable sizes, quantities and types, detailed cable routing for the feeders, and the rail reference circuit for NGD at the GBS only.

c. Review: CSC reviews and corrects designs with respect to the cabling, raceways, ductbanks, and cable trench requirements.

d. Procurement and Installation:
   1) GC implements raceway design, furnishes, and installs ductbanks, manholes, cable trenches, and stub ups in TPSS and GBS foundations, as indicated in the RFP Plans. See Section 34.20.51 – Traction Electrification System Interface Requirements.
   2) CSC is responsible to furnish and install all cable trays in trenches, and to furnish and install cables and seal the ends of conduits. CSC terminates all feeder cables at the TPSS and GBS and the rail reference cables for NGD within the GBS only as indicated in RFP Plans. See Sections 34.20.25 – DC Switchgear, 34.20.30 – Negative Grounding Device, 34.20.60 – Traction Power Cables, and 34.20.65 – Traction Power Raceways.

e. Completion of Work: CSC is responsible for the correct operation of the civil-to-systems and system to system interfaces and is required to fix and provide all necessary changes in design, materials, including all civil rework for any misdefined interfaces at its expense.

6. TPSS and GBS Facility Interfaces with the, HECO switch pad, the short circuit information for the ground grid design and installation of the foundations for and placement of the TES facilities.

a. Specification:
   1) For the TPSS facility sites, CSC coordinates with the HECO requirements and defines location of HECO switch pad, obtains quantities types and cable sizes, and defines detailed cable routing from HECO switch pad and HECO feeder poles to the TPSS foundations.
   2) For the GBS facility sites, CSC coordinates with the HECO requirements and defines location of HECO transformer pad, obtains quantities types and cable sizes, and defines detailed cable routing from HECO transformer pad to the GBS facility.
   3) For the TPSS and GBS facility sites CSC coordinates with HECO to obtain the utility short circuit information for defining the ground grid requirements. CSC provides weights, dimensions, equipment layouts, equipment orientation, sizes, and locations of TPSS and GBS facilities.
   4) CSC provides the HECO short circuit information to the GC to develop the ground grid design.
   5) HECO provides to the CSC the cable sizes, quantities types, and detailed cable routing requirements.
b. Design:

1) GC incorporates CSC/HECO system requirements and designs the TPSS and GBS foundations, the design for underground ductbanks, stub ups at the TPSS and GBS. GC incorporates CSC/HECO system requirements for the HECO switch pad design, its location, and stub ups and the raceway systems from the HECO interface points to the TPSS. GC incorporates CSC/HECO system requirements for the transformer pad design with anchor bolts, its location, and stub ups and the raceway systems from the HECO interface points to the GBS. The GC designs the ground grid size, its placement, the TPSS and GBS foundations pursuant to the weights, dimensions, equipment layout, and orientation as defined by the CSC/HECO system requirements as specified in Section 34 20 51 – TES Interface requirements.

2) CSC utilizes HECO defined requirements and confirms with HECO for designing the cable sizes, quantities and types, and detailed cable routing.

c. Review: CSC reviews and corrects designs with respect to all underground ductbanks, stub ups at the HECO switch and transformer pads those for the TPSS and GBS foundations and the ground grid size and locations.

d. Procurement and Installation:

1) GC implements design, furnishes, and installs underground ductbanks, underground pull box, stub ups. At the GBS sites GC provides the underground ductbanks from the HECO interface point to the HECO transformer primary connection and the secondary duct banks from the transformer to the GBS as indicated in the RFP Plans. The GC also provides HECO switch pad at TPSS sites, and transformer pad at GBS sites, TPSS and GBS foundations, and ground grids. At the GBS sites, the GC provides the ground rod and loose ground coil for the HECO supplies transformer. See Sections 34 20 51 – TES Interface Requirements and 33 70 00 Electric Utilities, for further requirements.

2) For the TPSS sites, HECO installs switch on the GC supplied switch pad or on pole placement locations and terminates feeder cables within the switch. HECO installs feeder cables into the TPSS facilities and terminates cables at metering sections as indicated in the RFP Plans. For the GBS sites, HECO provides and securely mounts the outdoor transformer on pad and terminates primary cables to the pad mounted transformer. HECO installs instrument transformers and outdoor meter as indicated in the RFP Plans. Refer to Section 33 70 00 – Electric Utilities, Section 34 20 10 – AC Switchgear, Section 34 20 51 – TES Interface Requirements, and Section 34 20 60 – Traction Power Raceways, for further requirements.

3) CSC provides all rigging necessary to lift and install TPSS and GBS and securely mounts the TPSS and GBS to the foundations in accordance with the approved Design Plans and with the requirements of the Division 34 Technical Provisions. CSC is responsible to furnish and install the electrical connections to the TPSS and GBS-facilities ground grid through the connection of the loose coils as indicated in the RFP Plans. For the GBS sites the CSC connects the loose ground coils to the HECO supplied transformer. Refer to Section 33 70 00 – Electric Utilities, Section 34 20 01 – Traction Electrification General...
Requirements, Section 34 20 05 – Prefabricated Enclosures, Section 34 20 10 – AC Switchgear, Section 34 20 19 – TES Grounding Requirements, Section 34 20 51 – TES Interface Requirements, and Section 34 20 60 – Traction Power Raceways, for further requirements.

4) CSC provides and coordinates with the GC for the stub up locations and exposed raceways at GBS including, meter pan service fused disconnect switch/circuit breaker, instrument transformer cabinet, splice can/pull box and all cabling from transformer to the manual transfer switch within GBS Prefabricated Enclosure. Refer to Section 34 20 10 – AC Switchgear, Section 34 20 50 – Miscellaneous Materials and Devices, Section 34 20 60 – Traction Power Cables, and Section 34 20 65 – Traction Power Raceways, and RFP Plans for further requirements.

5) CSC terminates all other cabling within the TPSS and GBS facilities. Refer to Section 34 20 10 – AC Switchgear and Section 34 20 60 – Traction Power Cables.

e. Completion of Work: CSC is responsible for the correct operation of the civil-to-systems and system-to-system interfaces and is required to fix and provide all necessary changes in design and materials, including all civil rework for any misdefined interfaces at its expense.

7. TPSS and GBS Facility Interfaces with the Drainage Corrosion protection system.

   a. Specification:
   1) CSC defines requirements for drainage corrosion protection underground ductbanks, handhole locations, and drainage cables.

   b. Design:
   1) GC designs drainage corrosion protection underground ductbanks and handholes.

   c. Review: CSC reviews and corrects designs with respect to all underground ductbanks, stub ups within the TPSS and GBS foundations for the handholes, and raceways for the drainage corrosion protection.

   d. Procurement and Installation:
   1) GC implements design, furnishes, and installs the drainage corrosion protection underground raceways, ductbanks, and handholes as indicated in the RFP Plans. See Section 34 20 51 – Traction Electrification System Interface Requirements.

   2) CSC is responsible to install the drainage corrosion cables from TPSS and GBS to the handhole, as indicated in the RFP Plans. See Section 34 20 60 – Traction Power Cables.

   3) CSC terminates the cables within the TPSS and GBS.

e. Completion of Work: CSC is responsible for the correct operation of the civil-to-systems and system-to-system interfaces and is required to fix and provide all necessary changes in design and materials, including all civil rework for any misdefined interfaces at its expense.

C. Maintenance and Storage Facility Civil Works:

1. Fiber Optic Communication Systems Interface to Yard TPSS Facilities for raceways and cables, the ETS/BLS System, and E-Telephone systems and those ETS/BLS stations throughout the MSF Yard to the Operations Control Center
(OCC) communications equipment room within the MSF Operations & Servicing Building.

a. Specification: CSC defines the equipment location, mounting requirements, and conduit sizes, and detailed conduit routing, end locations, and specifies exposed raceway and underground ductbanks at the Yard TPSS and BLS/ETS within the confines of the Yard and the ETS/BLS unit located at the Yard TPSS. The CSC specifies the cable sizes, quantities, and types and defines power connections to the ETS/BLS.

b. Design:
   1) MSFDBC incorporates CSC system requirements and develops designs for the location, mounting requirements, conduit size requirements, end locations, detailed conduit routing of the underground ductbanks at the Yard TPSS, and underground ductbanks and handholes required for the BLS throughout the MSF Yard.
   2) CSC designs the cable system, end locations, and detailed routing within the MSF Yard and support mounting provisions for the Yard ETS/BLS.

c. Review: CSC reviews and corrects designs with respect to the system requirements for the Yard BLS equipment location, mounting requirements, conduit size requirements, end locations, detailed conduit routing, and exposed raceways and underground ductbanks at the Yard TPSS and the BLS units throughout the MSF Yard.

d. Procurement and Installation:
   1) MSFDBC implements raceway design and furnishes and installs underground ductbanks, including hand holes at MSF Yard ETS/BLS to the MSF Operations & Servicing Building and OCC communication equipment room, as indicated in the Contract Documents. MSFDBC provides the foundations support and mounting provisions for the ETS/BLS within the MSF Yard, as indicated in the RFP Plans. MSFDBC to provide raceways from Yard Control Tower room to OCC Communication room. See Section 34 20 52 – Traction Electrification MSF Interface Requirements and Section 27 30 01 – Telephone Systems for further requirements.
   2) CSC is responsible to furnish, install, and terminate all copper and fiber optic type communication cables from ETS/BLS located at Yard TPSS to the Communications Interface Cabinet (CIC) within the Yard TPSS, as indicated in the RFP Plans. CSC is responsible to furnish, install, and terminate the FOCN cables from the Yard TPSS to the OCC communication equipment room. CSC is responsible to furnish, install, and terminate all communication cables from all ETS/BLS units to the OCC communication equipment room and seal the ends of conduits at Yard TPSS and the MSF Operations & Servicing Building interface manhole and the MSF OCC communication equipment room and Yard Control Tower. See Sections 27 13 01 – Fiber Optic Cabling Network and 34 20 52 – Traction Electrification System MSF Interface Requirements.

e. Completion of Work: CSC is responsible for the correct operation of the civil-to-systems and system to system interfaces and is required to fix and provide all necessary changes in design and materials, including all civil rework for any misdefined interfaces at its expense.
2. Train Control System for the secondary access to the MSF facility:
   a. MSFDBC to interface with the CSC for the Train Control System for the Secondary Access to the MSF facility as indicated in the RFP Plans and as described in Section 27 60 00 – SCADA System and Section 34 44 00 – Train Control System.

3. MSF Yard TPSS Facility Interfaces with the, HECO switch pad, the short circuit information for the ground grid design, and installation of the foundations and placement of the TES facilities.
   a. Specification:
      1) CSC coordinates with the HECO requirements and defines location of HECO switch pad, obtains quantities and types and cable sizes, and defines detailed cable routing location, mounting requirements, from HECO switch pad to the TPSS foundations and HECO feeder pole to GBS foundation. CSC coordinates with HECO to obtain the utility short circuit information for defining the ground grid requirements. CSC provides weights, dimensions, equipment layouts, orientation, sizes, and locations of TPSS facilities.
      2) CSC provides the HECO short circuit information to the MSFDBC to develop the ground grid design.
      3) HECO provides CSC the cable sizes, quantities and types, and detailed cable routing requirements.
   b. Design:
      1) MSFDBC incorporates CSC/HECO system requirements and designs the Yard TPSS and foundations, the design for underground raceways, ductbanks, cable trenches, the stub ups at the Yard TPSS MSFDBC incorporates CSC/HECO system requirements for the HECO switch pad design and its location and its stub ups and the raceway systems from the HECO interface points to the Yard TPSS. The MSFDBC designs the ground grid size, its placement, and the Yard TPSS foundations pursuant to the weights, dimensions, equipment layout, and orientation as defined by the CSC/HECO system requirements.
      2) CSC utilizes HECO defined requirements and confirms with HECO for designing the cable sizes, quantities and types, and detailed cable routing.
   c. Review: CSC reviews and corrects designs with respect to all underground raceways, ductbanks, cable trenches and stub ups at the HECO pad, and those for the Yard TPSS foundation, including the handholes and raceways for the ground grid size and locations.
   d. Procurement and Installation:
      1) MSFDBC implements design and furnishes and installs underground raceways, ductbanks, HECO switch pad, Yard TPSS foundations, and ground grids. See Section 34 20 52 – Traction Electrification System MSF Interface Requirements.
      2) HECO installs switch on the MSFDBC supplied switch pad or pole placement locations and terminates wires within the switch and pulls cable into the TPSS facilities and terminates cables as indicated in the RFP Plans. See Sections 33 70 00 – Electric Utilities and 34 20 10 – AC Switchgear.
3) CSC rigs and securely mounts the Yard TPSS to the foundation. CSC is responsible to furnish and install all electrical connections of the Yard TPSS facilities to the ground grid through the connection of the loose coils, as indicated in the RFP Plans. CSC terminates all cables within the Yard TPSS. See Section 34 20 01 – Traction Electrification System – General Requirements, Section 34 20 05 – Prefabricated Enclosures, and Section 34 20 18 - Traction Electrification System MSF Grounding Requirements.

e. Completion of Work: CSC is responsible for the correct operation of the civil-to-systems and system-to-system interfaces and is required to fix and provide all necessary changes in design, materials, including all civil rework for any misdefined interfaces at its expense.

4. MSF Yard TPSS Facility Interfaces with the Drainage Corrosion protection system
a. Specification:
   1) CSC defines requirements for drainage corrosion protection, underground ductbanks, handhole locations, and drainage cables.

b. Design:
   1) MSFDBC designs drainage corrosion protection, underground ductbanks, and handholes.

c. Review: CSC reviews and corrects designs with respect to all underground ductbanks, stub ups within the Yard TPSS foundation for the handholes, and raceways for the drainage corrosion protection.

d. Procurement and Installation:
   1) MSFDBC implements, design, furnishes, and installs the drainage corrosion protection underground raceways, ductbanks, and handholes, as indicated in the RFP Plans. See Section 34 20 52 – Traction Electrification System MSF Interface Requirements and Section 26 42 01 – Corrosion Control.

   2) CSC is responsible to install the drainage corrosion cables from TPSS and GBS to the handhole, as indicated in the RFP Plans.

   3) CSC terminates the cables within the TPSS and GBS. See Section 34 20 60 – Traction Power Cables.

e. Completion of Work: CSC is responsible for the correct operation of the civil-to-systems and system-to-system interfaces and is required to fix and provide all necessary changes in design and materials, including all civil rework for any misdefined interfaces at its expense.

5. Contact Rail System and Track Running Rail Interface with TES Feeder Cables and connection blocks, cross bonds, jumpers, shunt cables, feeder connection plates, connection blocks, and raceways from Yard TPSS.

a. Specification:
   1) MSFDBC defines contact rail system layouts, locations of expansion joints, insulator supports, and end approach assemblies.

   2) CSC defines the cable sizes, for the flexible cross bonding, jumpers, and shunt cables, cable connection plates and connection blocks, quantities and types, and connection to track running rails, and the detailed cable routing location, mounting requirements, exposed raceway conduit.
sizes, detailed conduit routing in respect to the MSFDBC defined Contact Rail system installation requirements, as indicated in the RFP Plans.

b. Design:
   1) MSFDBC incorporates CSC system requirements and designs the Contact Rail system per the CSC defined requirements for the cable sizes, quantities and types, detailed cable routing location, mounting requirements, exposed raceway conduit sizes, and detailed conduit routing.
   2) CSC designs the cable sizes, quantities and types, detailed cable routing location, mounting requirements, exposed raceway conduit sizes, detailed conduit routing, and from the MSFDBC designed Contact rail system layout, the connections to track running rails and locations of the connection blocks and contact rail feeder, jumper, and shunt connection plates.

c. Review: CSC reviews and corrects MSFDBC designs with respect to the Contact Rail system requirements, cable connections to contact rail and track running rails, and the raceway systems.

d. Procurement and Installation:
   1) MSFDBC implements Contact Rail design, furnishes, and installs the Contact Rail system. See Section 34 24 10 – Contact Rail System.
   2) CSC is responsible to furnish and install all exposed conduits, furnish and install cables and seal ends of conduits for the cross bonding, jumper and shunt cables, and install connection blocks and connection plates and cables to the Contact Rails and running rails from the Yard TPSS, as indicated in the RFP Plans. See Section 34 20 65 – Traction Power Raceways, Section 34 20 60 – Traction Power Cables, and Section 34 20 25 – DC Switchgear.

e. Completion of Work: CSC is responsible for the correct operation of the civil-to-systems and system-to-system interfaces and is required to fix and provide all necessary changes in design and materials, including all civil rework for any misdefined interfaces at its expense.

6. MSF Civil Works Wayside dc Electrically Operated Disconnects Switches (EOS) interface in Yard with Contact Rail and MSF Operations and Servicing Building.

a. Specification: CSC defines the EOS equipment locations, mounting requirements, conduit sizes, and detailed conduit routing, end locations, and specifies underground ductbanks to the EOS and the Contact Rail and the Track running rails via the manholes and handholes as indicated in the RFP Plans. CSC defines raceways within the MSF Operations & Servicing Building for control and operating power requirements from the OCC Communications equipment room and the power panels within the MSF Operations and Servicing building, respectively. The CSC specifies the connection blocks, cable sizes, quantities and types for the Traction Power cables, the control and the low voltage 480 V ac power to operate the EOS units.

b. Design:
   1) MSFDBC incorporates CSC system requirements and develops designs for the EOS equipment location, pads, mounting requirements, conduit
size requirements, end locations, detailed conduit routing of the underground ductbanks, and those from the EOS units to the Contact Rail.

2) MSFDBC designs the underground ductbanks, handholes, and manholes at the MSF Operations and Servicing building and any exposed raceways within the MSF Operations and Servicing building required to supply the EOS operating power from the low voltage 480 V ac power panels located within the MSF Operations & Servicing Building.

3) MSFDBC designs the underground ductbanks, and the exposed raceways within MSF Operations & Servicing Building required to the Communication Interface Cabinets (CIC) in the OCC Communications equipment room for the control and indication requirements of the EOS.

4) CSC develops design of cables system and end locations and detailed routing within the MSF Yard.

c. Review: CSC reviews and corrects designs with respect to the system requirements for the EOS, the Contact Rail, the Track running rail, the MSF EOS mounting requirements, conduit size requirements, end locations, detailed conduit routing and exposed raceways and underground raceway, and ductbanks at the MSF Operations & Servicing Building Yard Tower, the power panel’s connections within the MSF Operations & Servicing Building, and the cables for the control and low voltage 480 V ac power to operate the EOS units.

d. Procurement and Installation:

1) MSFDBC implements raceway design, furnishes, and installs underground ductbanks, manholes, EOS switch pads and raceways to and within the MSF Operations & Servicing Building, and those raceways from the EOS to the Contact Rail and Track Running Rails as indicated in the RFP Plans. See Section 34 20 52 – Traction Electrification System MSF Interface Requirements and Section 34 24 10 – Contact Rail System.

2) CSC is responsible to furnish and install all cables from EOS to the Contact Rail, to the track running rail, the cables to the OCC communications equipment room and the cables to the power panel within the MSF Operations and Servicing Building for the EOS units as indicated in the RFP Plans and as specified in Section 34 20 01 – Traction Electrification – General Requirements, Section 34 20 35 – Control and Annunciation System, Section 34 20 55 – Wayside DC Disconnect Switches and Section 34 20 60 – Traction Power Cables.

e. Completion of Work: CSC is responsible for the correct operation of the civil-to-systems and system to system interfaces and is required to fix and provide all necessary changes in design and materials, including all civil rework for any misdefined interfaces at its expense.

7. MSF Vehicle Shop TPSS MSF Interfaces:

a. MSFDBC to coordinate interface with the CSC for the Vehicle Shop TPSS alarms and indications to the Yard Control Tower as indicated in the RFP Plans. See Section 34 30 05 – Shop Traction Power Substation and Section 34 20 52 – Traction Electrification System MSF Interface Requirements.
b. MSFDBC to coordinate and interconnect the Vehicle Shop TPSS ground grid with MSF operations building ground grid. See Section 34 20 18 – Traction Electrification System MSF Grounding Requirements.

1.04 QUALITY ASSURANCE
A. Refer to General Conditions for quality assurance requirements and procedures.

PART 2 – PRODUCTS
NOT USED

PART 3 – EXECUTION
NOT USED

END OF SECTION
SECTION 34 20 80
TRACTION ELECTRIFICATION SYSTEM TESTING

PART 1 – GENERAL

1.01 SUMMARY

A. Description: This Section covers the Contractor requirements for testing and installation verification of the Work to be performed by the Contractor on all Traction Power Substations (TPSS), Gap Breaker Stations (GBS), equipment, materials, and accessories furnished under this Contract. 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 the City. Start-up and on-site integration test shall be performed as specified in the Technical Provisions TP-02, “Verification, Testing and Acceptance”.

B. Section Includes:
   1. General
   2. Responsibility
   3. Rejection and Retesting
   4. Coordination
   5. Factory Tests
   6. Field Tests
   7. Acceptance Records

C. Related Sections:
   1. Section 34 20 01 – Traction Electrification - General Requirements
   2. Section 34 20 05 – Prefabricated Enclosures
   3. Section 34 20 10 – AC Switchgear
   4. Section 34 20 15 – Rectifier Transformer
   5. Section 34 20 20 – Traction Rectifier
   6. Section 34 20 25 – DC Switchgear
   7. Section 34 20 30 – Negative Grounding Device
   8. Section 34 20 35 – Control and Annunciation System
   9. Section 34 20 40 – Emergency and Transfer Trip System
   10. Section 34 20 45 – DC Control Power System
   11. Section 34 20 50 – Miscellaneous Materials and Devices
12. Section 34 20 55 – Wayside DC Disconnect Switches

13. Section 34 20 60 – Traction Power Cables

1.02 PRICE AND PAYMENT PROCEDURES

A. General: Separate measurement or payment will not be made for the Work required under this Section. All cost in connection with Work specified herein will be considered to be included with the related item of work in the General Conditions requirements, or incidental to the Work.

1.03 CODES, STANDARDS, AND RECOMMENDED PRACTICES

A. American National Standards Institute (ANSI):

1. ANSI C29.1 Test Methods for Electrical Insulators

2. ANSI C34.2 Practices and Requirements for Semiconductor Power Rectifiers

3. ANSI C37.04 Rating Structure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis

4. ANSI C37.06 Preferred Ratings and Related Required Capabilities for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis

5. ANSI C37.09 Test Procedures for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis

6. ANSI C37.10 Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis

7. ANSI C37.11 Electrical Control for AC for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis or a Total Current Basis

8. ANSI C37.14 Low-Voltage DC Power Circuit Breakers Used in Enclosures

9. ANSI C37.16 Preferred Ratings, Related Requirements and Application Recommendations for Low-Voltage Power Circuit Breakers and AC Power Circuit Breakers

10. ANSI C37.17 Trip Devices for AC and General-purpose DC Low-Voltage Power Circuit Breakers

11. ANSI C37.20 Switchgear Assemblies Including Metal-Enclosed Bus

12. ANSI C37.34 Test Code for High-Voltage Air Switches

13. ANSI C37.90 Relays and Relay Systems Associated with Electrical Power Apparatus

14. ANSI C37.100 Definitions for Power Switchgear
15. ANSI C39.1 Requirements for Electrical Analog Indicating Instruments
16. ANSI C39.5 Safety Requirements for Electrical and Electronic Measuring and Controlling Instrumentation
17. ANSI C57.12.91 Test Code for Dry-Type Distribution and Power Transformers
18. ANSI C57.13 Requirements for Instrument Transformers
19. ANSI C57.18 Pool-Cathode Mercury-Arc Rectifier Transformers

B. Electronic Industries Association (EIA):
   1. RS-282 Standards for Silicone Rectifier Diodes and Stacks

C. Institute of Electrical and Electronics Engineers (IEEE):
   1. IEEE 81 Guide for Measuring Ground Impedance of a Ground System
   2. IEEE 383 Standard for Qualifying Class 1 E Electric Cables and Field Splices for Nuclear Power Generating Stations

D. National Electrical Manufacturer’s Association (NEMA):
   1. NEMA BU I Busways
   2. NEMA EI 2 Instrument Transformers
   3. NEMA SG 3 Low-Voltage Power Circuit Breakers
   4. NEMA SG 4 AC High-Voltage Circuit Breakers
   5. NEMA SG 5 Power Switchgear Assemblies
   6. NEMA SG 6 Power Switching Equipment
   7. NEMA TR 1 Audible Sound Levels for Dry Type Transformers
   8. NEMA WC 3 Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (ICEA S-19-81)
   9. NEMA WC 8 Ethylene-Propylene-Rubber-Insulated Wire and Cable

E. National Fire Protection Association (NFPA):
   1. NFPA 72H Guide for Test Procedures for Protective Signaling Systems

1.04 SUBMITTALS

A. General: Refer to General Conditions for Submittal Procedures, and for Shop Drawings, Product Data, and Samples requirements and procedures.
B. Submit the following in accordance with Section 34 20 01 – Traction Electrification - General Requirements:

1. Test Program Plan.
2. Test Procedures.
3. Installation verification reports.
4. Test reports.
5. Test equipment data and calibration certificates.
7. Training Manuals and Equipment: Training manuals and equipment shall conform to the requirements of the Technical Provisions TP-03, “O&M Performance Requirements”.

1.05 QUALITY ASSURANCE

A. General: Refer to General Conditions for quality assurance requirements and procedures.

B. Comply with all applicable Federal, State, and Local Laws, Regulations, and Codes including those referenced in Article 1.03.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Provide all tools, instruments, calibration devices, meters, and other equipment to connect, monitor, adjust, and perform the field tests.

B. Provide spare parts as required to conduct the start-up and testing.

C. Furnish all other equipment and personnel services necessary to test and commission the TPSS, GBS, the Electrically Operated Disconnect Switches (EOS), Emergency Trip Station/Blue Light Station (ETS/BLS) System, Transfer Trip System, and Traction Power Cables including participation in Systems Integration Testing as defined in the Technical Provisions TP-02, “Verification, Testing and Acceptance”.

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 and warranted.

PART 3 – EXECUTION

3.01 GENERAL

A. This Section covers the requirements for the factory and field tests to be performed by the Contractor on all TPSS, GBS, EOS Disconnect Switches, ETS/BLS System, Transfer Trip
System, and Traction Power Cables equipment, materials, and accessories, including equipment, materials, and accessories required for the substations and GBS furnished under this Contract. Factory testing shall not commence until all designs affecting the respective equipment has been approved. In addition, test procedures shall have been approved at least 15 days prior to the start of testing.

B. Test Witnessing: The City reserves the right to witness all tests whether conducted by the Contractor, by an independent agency, or by the Contractor’s suppliers. If the City determines not to witness a test or tests, test reports shall nevertheless be submitted to the City for approval. Test reports shall be signed and certified by all witnessing parties. Notify the City of tests.

3.02 RESPONSIBILITY

A. Responsible for all tests performed under this Contract. Furnish all test instruments and other equipment and materials necessary for performing all tests required prior to shipment. All test equipment shall be calibrated within 30 days prior to use, unless otherwise approved by the City. Proof of calibration shall be submitted with all test reports. Should there be loss of equipment or damage to such equipment as a result of tests, replace the damaged equipment and/or repair such equipment. Replacement of damaged equipment shall include all costs, including but not limited to, removing damaged equipment, furnishing, transporting, and installing replacement equipment, and retesting.

3.03 REJECTION AND RETESTING

A. Failure of equipment to meet test specifications or ratings shall be sufficient grounds for rejection of equipment. Rejected equipment shall be retested after reworking. If modifications or changes affect any drawings, diagrams, or other documents previously submitted to and accepted by the City, revised drawings or diagrams shall be submitted for the City’s approval to show proposed changes before changes or modifications are made on the equipment. Modifications or changes, which do not warrant revision of a drawing, shall still be furnished to the City with notice of the retest schedule. If it is not practicable to rework rejected equipment, new equipment shall be manufactured. The requirements for drawings and design calculations of the original unit shall be applicable to the new unit. The entire cost of the rework or the new unit shall be borne by the Contractor, including retesting and the cost of witnessing retesting, including that of the City.

3.04 COORDINATION

A. No field testing shall begin until all equipment installation has been completed and verified.

3.05 FACTORY TESTS

A. Factory tests shall include design and production tests to be performed by the Contractor, its supplier, or a testing agency prior to shipment of the equipment. At his expense, conduct pre-delivery tests followed by a formal Factory Acceptance Test (FAT) on each TPSS, GBS and EOS following completion of manufacture, and before delivery to the City. These pre-delivery tests shall include visual and measured inspections, as well as testing the total TPSS operation as identified in the Technical Provisions. The tests shall be conducted and documented in accordance with the Test Program Plan submitted to the...
City and subject to City’s approval. No traction power equipment shall be shipped from the final point of manufacturing prior to City’s approval of the FAT.

B. The FAT shall be scheduled and conducted with sufficient notice so that they may be witnessed by the City, at a minimum, two weeks prior to the tests. The written results of the FAT, and any other tests, shall be filed with the Assembly Inspection Records for each TPSS, GBS, and EOS. Delivery of each TPSS, GBS and EOS shall require written authorization of the City. An executed copy of the authorization shall accompany the delivery of each TPSS, GBS, and EOS. Except where indicated, the City may waive the requirements for factory design tests upon approval of test procedures, test reports, and/or certified documentation of like equipment. Test reports on like equipment or materials shall be submitted for the factory design tests, which may be waived by the City. The City reserves the right to waive any tests, and the City’s decision will be final.

C. 15 kV AC Circuit Breakers:

1. Design Tests: The following tests indicated in ANSI C37.09 as “Design Tests” shall be performed on one 15 kV circuit breaker, in addition to the radio influence voltage tests described in NEMA S G4:
   a. Rated maximum voltage
   b. Rated voltage range factor
   c. Rated frequency rated continuous current-carrying tests
   d. Short-circuit rating
   e. Rated standard operating duty Rated permissible tripping delay rated interrupting time
   f. Rated re-closing time
   g. Dielectric withstand tests including rated low frequency withstand voltage and rated full-wave impulse withstand voltage
   h. Rated control voltage
   i. Load current switching
   j. Mechanical life

2. Production Tests: The following tests indicated in ANSI C37.09 as “Production Tests” shall be performed on all 15 kV circuit breakers:
   a. Current transformer
   b. Nameplate check
   c. Resistors, heaters, and coil check
   d. Control and secondary wire check
   e. Clearance and mechanical adjustment check
   f. Mechanical operation
   g. Timing
   h. Stored-energy system
   i. Electrical resistance of current path Low-frequency withstand voltage

D. 15 kV Nominal AC Switchgear:

1. Design Tests: The following tests indicated in ANSI 37.20 as “Design Tests” shall be performed on one 15 kV nominal rated metal-clad ac switchgear assembly:
a. Dielectric tests including power frequency withstand, impulse withstand, and bus bar insulation  
b. Rated continuous current  
c. Momentary current  
d. Interrupting  
e. Mechanical operation  
f. Sequence  
g. Flame retardant

2. Production Tests: The following tests indicated in ANSI C37.20 as “Production Tests” shall be performed on all 15 kV nominal rated metal-clad ac switchgear assemblies:
   a. Dielectric  
   b. Mechanical operation  
   c. Grounding of instrument transformers cases  
   d. Electrical operation and control wiring tests including control wiring continuity, control wiring insulation, polarity, and sequence

E. Rectifier Transformer:

1. Design Tests: The following tests shall be performed on one rectifier transformer. These tests will not be waived.
   a. Commutating reactance tests as described in ANSI C34.2.  
   b. Short-circuit tests as indicated in ANSI C57.12.01 and C57.12.91 shall be performed to evaluate fully the capability of all windings. At least one extreme of the tap range shall be used in the tests. Faults shall be applied on the secondary terminals.  
   c. Dielectric-impulse with positive polarity waves as described in ANSI C57.12.01 and C57.18, as applicable. The impulse tests shall include one application of a reduced full-wave, two applications of a chopped wave, followed by one application of a full-wave. These tests shall be performed after the short-circuit tests.  
   d. Noise level tests shall be performed in accordance with the requirements as described in Section 34 20 01 – Traction Electrification - General Requirements

2. Production Tests: As applicable, the following tests indicated in ANSI C57.12.01 and C57.18 shall be performed on all rectifier transformers:
   a. Resistance measurements of all windings on rated voltage connection and on all taps  
   b. Ratio tests on the rated voltage connection and on all taps  
   c. Polarity and phase relation tests on the rated voltage connection  
   d. Impedance and load losses at rated current on the rated voltage connection and on all taps, including excitation loss and excitation current  
   e. Dielectric low-frequency withstand, including applied-potential and induced-potential  
   f. Partial discharge tests in accordance with ANSI C57.12.01.
F. Rectifier:
   1. Design Tests: The rated current tests indicated in ANSI C34.2 shall be performed on one rectifier.
   2. Production Tests: The following tests indicated in ANSI C34.2 shall be performed on all rectifiers:
      a. Dielectric strength
      b. Rated voltage

G. Transformer-Rectifier Unit: Design tests shall be performed on one transformer-rectifier unit including accessories and the busway connecting the transformer in accordance with ANSI C34.2. The tests shall verify efficiency, voltage regulation, and displacement power factor at loads of zero, 25, 50, 75, 100, 150, 300, and 450 percent of rated load.

H. Negative Grounding Device:
   1. Design Tests: Design Tests shall be performed on one NGD in accordance with ANSI C37.14. If these tests have already been performed in accordance with the ANSI standards, Contractor may submit for approval by the City, the test certificate from the laboratory in lieu of physically performing the tests. If the NGD has been modified since the certification, the NGD must be re-certified in accordance with the ANSI requirements.
      a. Dielectric withstand
      b. Continuous current
      c. Short-circuit current withstand
      d. Electrical endurance
      e. Mechanical endurance
   2. Production Tests: The following tests indicated in ANSI C37.14 as "Production Tests" shall be performed on all dc circuit breakers:
      a. Control and secondary wiring check
      b. Dielectric withstand
      c. Mechanical operation
      d. Calibration

I. DC Circuit Breakers:
   1. Design Tests: Design Tests shall be performed on one dc feeder breaker in accordance with ANSI C37.14. If these tests have already been performed in accordance with the ANSI standards, Contractor may submit for approval by the City, the test certificate from the laboratory in lieu of physically performing the tests. If the breaker has been modified since the certification, the breaker must be re-certified in accordance with the ANSI requirements.
      a. Dielectric withstand
      b. Continuous current
      c. Short-circuit current interrupting
      d. Mechanical endurance
2. Production Tests: The following tests indicated in ANSI C37.14 as “Production Tests” shall be performed on all dc circuit breakers.
   a. Control and secondary wiring check
   b. Dielectric withstand
   c. Mechanical operation
   d. Calibration

J. DC Switchgear:

1. Design Tests: The following tests, indicated in ANSI C37.20 as “Design Tests” shall be performed on one dc switchgear assembly. These tests shall not be waived:
   a. Dielectric including power frequency withstand, impulse withstand and bus bar insulation
   b. Rated continuous current
   c. Momentary current
   d. Interrupting
   e. Mechanical operation
   f. Sequence
   g. Flame-retardant test

2. Production Tests: The following tests indicated in ANSI C37.20 as “Production Tests” shall be performed on all dc switchgear assemblies:
   a. Dielectric
   b. Mechanical operation
   c. Electrical operation and control wiring including control wiring continuity, control wiring insulation, polarity, and sequence

K. Busways:

1. Design-Tests: The following tests indicated in ANSI C37.20 as “Design Tests” shall be performed on one busway:
   a. Dielectric including 60 Hz withstand and impulse withstand
   b. Momentary

2. Production Tests: Power frequency withstand tests indicated in ANSI C37.20 as “Production Tests” shall be performed on all busways with all accessories in place.

L. Battery:

1. Design Tests: Design tests indicated in IEEE 1106-2005 as “Service Tests” shall be performed on one battery bank.

2. Production Tests: Production tests described in IEEE 450 as “Acceptance Tests” shall be performed on all battery banks.

M. Battery Charger:

1. Design Tests: The following tests described in NEMA PV5 as “Design Tests” shall be performed on one battery charger:
   a. Dielectric
b. Voltage adjustment
c. No-load
d. Temperature rise
e. Current-limit
f. Short-circuit static voltage deviation
g. Efficiency measurement
h. Power factor measurement
i. Ripple voltage measurement
j. Audible noise
k. Stability and response
l. Transient voltage withstand

2. Production Tests: The following tests indicated in NEMA PV5 as “Production Tests” shall be performed on all battery chargers:
   a. Dielectric
   b. Voltage adjustment
c. No-load
d. Current limit
e. Ripple voltage measurement

N. Station Service Equipment:

1. Design Tests: Design tests indicated in ANSI C57.12 shall be performed on one auxiliary power transformer.
2. Production Tests: Production tests indicated in ANSI C57.12 as “Routine Tests” shall be performed on all auxiliary power transformers.
3. Distribution Panels: The manufacturer’s standard production tests shall be performed on all ac and dc distribution panels.

O. Wire and Cables:

1. Production Tests:
   a. Production tests shall be performed on all rubber-insulated wire and cable in accordance with ANSI/ICEAS-95-658/NEMA WC70.
   b. 2400 Volt dc Traction Power Cables: Factory testing of completed cable shall be performed in accordance with NEMA WC71 (ICEA S-96-659) and UL 1072 for the 5 kV rated power cables; and in accordance with NEMA WC70 (ICEA S-95-658) and UL 44 for the 2 kV rated control power cables.
   c. Refer to Section 34 20 60 – Traction Power Cables, for other test requirements.

P. Relays, Meters, Transducers, and Instrument Transformers:

1. All relays, meters, transducers, and instrument transformers shall be tested in the factory for accuracy, performance, operation, and correct setting and calibration, in accordance with ANSI C12.1, ANSI C37.90, ANSI C39.1, and ANSI C57.13. The relay coordination shall be by the Contractor.
2. Relay and transducer testing, setting, and calibration shall be separately bench-tested from the overall inspection and testing. Relays and transducers shall be tested in accordance with ANSI C37.90.1 for surge withstand capability, except where certified test reports are available for the same model to prove that such tests have been passed successfully by identical equipment.

3. Test current and voltage shall be injected into the current and voltage circuits at the instrument transformer terminals to ensure that the protective relays are polarized correctly and trip the respective circuit breakers as designed, and to ensure that instruments read correctly and meters are calibrated accurately.

4. Instruments and transducers shall be checked for accuracy at quarter, half, three-quarters, and full-range points.

5. After the relays have been calibrated with the proper settings, a small white card stating the settings and date of calibration shall be placed in the relay case.

Q. Control Wiring:

1. Verify in the factory that the wiring conforms to the approved control schematics and wiring diagrams. Wiring continuity and proper termination shall be checked completely, including interconnections at shipping splits.

2. All wiring within equipment enclosures and among equipment enclosures shall be tested as described below:
   a. By means of high potential, continuity, and operations tests, all wiring shall be checked for accuracy, intended functionality, ground connections, and insulation integrity.
   b. All wiring exposed to 1000 V dc shall be given a high-potential test of 4600 V, 60-Hz voltage to ground for 1 minute. Low voltage wiring shall be subjected to 1500 V, 60-Hz voltage to ground for 1 minute.
   c. Insulated cables and wires shall be certified to have passed the design and production test in accordance with the applicable ICEA, IEEE, and NEMA standards, including the flame propagation test.

R. DC Electrically Operated Disconnect Switch (EOS):

1. Design Tests: The following tests described in ANSI 37.34 as "Design Tests" shall be performed on one EOS:
   a. Dielectric
   b. No-load
   c. Temperature Rise
   d. Short time Current
   e. Transient Voltage Withstand

2. Production Tests: The following tests indicated in NEMA PV5 as "Production Tests" shall be performed on all EOS:
   a. Operation of all components and controls:
      1. Operation of Manual Handle
      2. Remote/Local Selector
      3. Local and Remote Open/Close Operations
4. No-load Safety Circuitry Interlocks
   b. Power frequency Dielectric withstand
   c. Electric resistance of current path

S. TPSS and GBS (where applicable): The following tests shall be performed with all equipment installed in each substation enclosure prior to shipment, unless otherwise indicated:

1. Temperature Rise Tests: These tests shall be performed on one complete substation, on the duty cycle indicated to verify the following:
   a. The limit of transformer temperature rise measured by resistance shall be as indicated in ANSI 57.18 and NEMA RI-9 for 428 degrees Fahrenheit insulation.
   b. The limit of temperature rise for the rectifier shall be as indicated in ANSI C34.2 and NEMA RI-9.
   c. The limit of temperature rise for the busway connecting the transformer and rectifier shall be as indicated in ANSI C37.20.
   d. Thermocouples: The number and locations of thermocouples or approved equal devices shall be as indicated in the Technical Provisions. The thermocouple with the highest temperature reading shall be considered when determining the limit of temperature rise.
      1) Transformer: A minimum of three thermocouples shall be embedded and permanently soldered to the windings of each transformer coil, unless otherwise approved by the City. The first thermocouple in each coil shall be located 3 to 6 inches from the top of the coil, the second in the middle of the coil, and the third 3 to 6 inches from the top of the coil.
      2) Busway: A minimum of four thermocouples shall be used and located as indicated in ANSI C37.20.
      3) Rectifier: A minimum of one thermocouple shall be located on each phase of the rectifier, with their locations selected by the City.
   e. Extra Heavy Duty Traction Cycle: The transformer-rectifier unit shall be in operation at 100 percent full-load until all parts have reached constant temperature, but not for less than 6 hours, before applying overloads. After constant temperature has been reached, the transformer-rectifier unit shall be operated at 150 percent full-load for two hours with five cycles of 300 percent full-load for 1 minute duration, each equally spaced throughout the two-hour period, followed by a 450 percent full-load for 15 seconds at the end of the two-hour period. The temperature limits of the transformer-rectifier unit shall not be exceeded during the heat run tests.

2. Continuity and Dielectric Tests: Perform continuity and dielectric tests on all equipment according to applicable ANSI and NEMA standards.

3. Functional and Operating Tests of all Devices and Circuits.

4. Protective Devices: Proper operation and setting of all protective devices shall be verified to be in accordance with the protective device coordination study, which shall be submitted to the City for approval.

5. Thermostats: Settings of all heater thermostats shall be checked.

6. Functioning and control of the cooling equipment and its control circuitry.
7. Reverse Current Trip: Apply 25, 50, 75, and 100 Amperes in the reverse direction to verify that the direct acting reverse current trip device (No. 32) trips the 15 kV ac circuit breaker and main dc circuit breakers.

8. Smoke Detection System: Test the smoke detection system for continuity and correct operation. The concealed calibrated test feature in each ionization detector shall be used to check operational integrity of the detection chamber. Each ionization detector shall be operated to ensure that the indicating lamp at the annunciator panel is lit. After completion of the test, the ionization detectors shall be set for the correct sensitivity.

9. Weatherproofing: One empty substation enclosure shall be tested in accordance with the weatherproofing test for outdoor metal-enclosed switchgear in accordance with ANSI C37.20.

10. Programmable Logic Controller and all associated hardware and software components.

3.06 FIELD TESTS

A. Testing Wire and Cables:

1. By means of high potential, continuity, and operations tests, all wiring shall be checked for accuracy, intended functionality, ground connections, and insulation integrity.

2. All wiring exposed to 1000 V dc shall be given a high-potential test of 4600 V, 60-Hz voltage to ground for 1 minute. Low voltage wiring shall be subjected to 1500 V, 60-Hz voltage to ground for 1 minute.

3. Insulated cables and wires shall be certified to have passed the design and production test in accordance with the applicable ICEA, IEEE, and NEMA standards, including the flame propagation test.

4. 2400 Volt Traction Power Cables:
   a. Cables shall be attached to dc switchgear cable supports, but not terminated, prior to conducting insulation resistance and high potential test.
   b. Perform Insulation Resistance (IR) and Polarization Index (PI) Tests in accordance with IEEE Standard 43-2000,
   c. The IR and PI tests shall be performed using 5000 V test voltage.
   d. Minimum acceptable insulation resistance and polarization index values shall be based on ICEA and cable manufacturer’s recommendations, and shall be subject to the City’s approval.
   e. Perform the IR and PI tests, after cable installation, but before splicing or terminating; then, following the splicing and terminating, carry out the IR and PI tests on each cable, with the test voltage applied between the conductor and ground.
   f. Follow appropriate safety precautions during the tests, such as handling megohmmeter terminals and cable conductors through insulating gloves.
   g. If cable failure occurs on any specified field test, correct the deficiency and retest. If the test fails again, replace the entire cable segment at no extra cost to the City.
B. Testing of Substations: Perform the field tests indicated after installation of the substations. Verify that all substations are properly installed, connected, and in operable condition. No equipment shall be energized or placed in the operating mode until approved by the City. Cooperate with the local electrical utility company by allowing them to conduct harmonic distortion tests during commissioning of the first substation. The Contractor’s test engineer shall be present during the utility harmonic testing.

1. Mechanical Tests: Perform mechanical checks on the physical integrity of all substation equipment in all substations.

2. Functional and Operational Tests: Perform functional and operational tests to verify that all equipment functions in accordance with approved control schematics. After successfully testing each function, the function shall be checked off on the applicable control schematic with a yellow marker and on the detailed step-by-step test procedures.

3. Short-Circuit Tests:
   a. Perform low-level fault tests to verify the proper calibration and setting of the rate-of-rise relays. In addition, tests shall be performed to verify that low-level faults can be distinguished from train starting currents of up to a maximum of two 4-car trains. The train starting tests shall be carried out with the trains provided by the City.
   
   b. Low-level short-circuit faults shall be applied at various locations along the track to obtain sufficient data to verify proper operation of the rate-of-rise relays in all substations furnished under this Contract. Proper operation shall require the rate-of-rise relay to close its contact to trip the feeder breaker associated with the fault. Low-level fault tests shall be performed in two phases as follows:
      1) Low-level fault tests shall have only one substation energized and connected to the section of contact rail normally fed by a minimum of two substations. Existing substations in this section will be electrically disconnected during the tests. If deemed necessary by the City, two or three sections of contact rail shall be electrically connected during the tests.
      2) Low-level fault tests shall have two or more substations energized and connected to the section of contact rail normally fed by a minimum of two substations. Prior to the preparation of the test procedures, obtain input from the City on the number of substations required to be energized during the tests and the locations of the tests. If deemed necessary by the City, two or three sections of contact rail shall be electrically connected during the tests. A fault applied in the immediate vicinity of one substation will be seen as a bolted fault by this TPSS, and a low-level fault by the other substation.
         a) The 15 kV ac circuit breaker and one dc feeder breakers of each substation shall all be monitored simultaneously to show the status of each circuit breaker during and after each short-circuit application. In addition, each phase of the 15 kV ac circuit breaker shall be monitored. Test results, such as total inrush current, steady-state, fault current, impulse time of faulted unit, clearing time of faulted unit, clearing time of other unit, and primary system capacity shall be recorded on oscillographs. All data recorded on oscillographs shall be properly labeled and identified.
c. All equipment, including the substation enclosure, shall be inspected for damage and loose bolts after each short circuit test. Failure to withstand these fault tests or to coordinate or meet specified requirements shall be reason for rejection of the equipment.

4. Train Starting Tests: Proper operation and coordination of the dc feeder circuit breaker relaying shall be verified during starting of different train consists at the substation. The weight of the vehicle to be simulated during this test shall be based on the AW2 Loading.

5. Noise Level Tests: Perform noise level tests on two new substations to verify that the maximum noise level measured in accordance with Section 34 20 01 – Traction Electrification - General Requirements. Noise level readings shall be taken while one or two trains are accelerating in the immediate vicinity of the substation so that its load is approximately 150 percent of the nominal. One meter shall be used per side with a total of four readings taken simultaneously for each set of readings. A minimum of 10 sets of readings shall be taken. Ambient noise level shall be established with meters in place and the station de-energized. This reading shall be taken before each test reading is taken under loaded conditions.

C. Testing of dc Electrically Operated Disconnect Switches:

1. Demonstration of proper functioning of operational testing shall be performed to verify functional performance of each of the Disconnect Switches prior to energizing of the Contact Rail. Verify correct operation of all Disconnect switches installed under this Contract, and demonstrate to the satisfaction of the City the intended operation as specified.

2. Furnish equipment and instruments required to perform the following tests, under the observation of the City, and submit certified reports of all tests:
   a. Test circuit connections in accordance with accepted wiring diagrams.
   b. Test that insulation resistance to ground of non-grounded connected conductors are a minimum of 10 mega-ohms.
   c. Test equipment enclosures for continuity to the grounding system where applicable in accordance with the manufacturer’s requirements.
   d. Test local operation of the Traction Power dc circuit with applied 775 V dc under No-Load conditions.
      1) When testing, operate EOS locally and test all mechanisms a minimum of 10 times with each circuit continuously energized for a minimum of 1/2 hour.
         a) Verify that dc power has been disconnected at the Contact Rail.
         b) Verify that the status indication contacts have been exercised at the EOS interface terminal blocks.

3. Verify EOS control, operation, and response indication from the Yard Control Tower has been met in accordance with the approved design shop drawings.

D. Transfer Trip and Emergency Trip Tests:

1. Transfer trip test shall be performed with minimum of three consecutive substations energized. The test plan and procedures shall be devised to confirm the proper
operation of the transfer tripping system, as well as the load measuring and auto-reclosing system in multiple feed contact rail sections.

2. Emergency Trip Test shall be performed to verify the operation of the system based on the ETS Block Diagrams and ETS Tripping Charts as indicated in the RFP Plans.

3.07 ACCEPTANCE RECORDS

A. Records shall be made of all tests listed herein, in accordance with the requirements of the General Conditions.

END OF SECTION
PART 1 – GENERAL

1.01 SUMMARY

A. Description:

1. These Train Control requirements detail the functional requirements for turnkey services, including the design, manufacture, installation, and test for an Automatic Train Control (ATC) system on the Honolulu High-Capacity Transit Corridor Project (HHCTCP) system. The purpose of this Section is to describe all requirements necessary for the ATC system to meet the Contract and to identify external constraints. They therefore address the following:
   a. Performance requirements of Train Control subsystems
   b. Interfaces between the Train Control system and other subsystems
   c. External constraints imposed by nature, legislation, and the City
   d. The system is depicted on the straight line diagram in the RFP Plans

2. The Driverless ATC system for mainline comprises a number of subsystems, including:

   a. An Automatic Train Supervision (ATS) subsystem (located at the main Operations Control Center (OCC)) – That function whereby the ATC system monitors train operation and provides controls, indications, schedule keeping, management data acquisition, and reporting automatic route initiation, performance modification, and automatic dispatching necessary to maintain intended traffic patterns and minimize the effect of train delays on the operations schedule. The following function shall be included in the ATS function:
      1) A Train Tracker system
      2) An Automatic Route Setting (ARS) system

   b. An Automatic Train Protection (ATP) subsystem – That function whereby the ATC system assures and maintains safe train operations. No subsystem malfunction or component failure shall result in unsafe train operations. The ATP function shall provide a train detection system that monitors the train’s motion, safe train separation, speed limit enforcement, route security through interlocking, traffic direction, safe manual coupling and uncoupling of vehicles and vehicle no motion detection. The ATP function shall include vehicle door operation with prevention of vehicle door operation when train is not properly berthed at a station. Additionally, the following function shall be included in the ATP function:
      1) Broken rail detection
      2) Protection against unauthorized movements onto the mainline
      3) A track safety system for the protection of staff working on the line
      4) Vehicle Roll-back Protection
c. An Automatic Train Operation (ATO) subsystem – That function whereby the ATC system performs operating mode control, automatic speed regulation, fault/data logging, train reversal, programmed station stopping, train berthing verification at station platforms and skip stopping.

d. A wayside Train Control system (for the Maintenance and Storage Facility (MSF)):
   1) Devices for the protection of unauthorized movements within the MSF for the manually operated trains
   2) A control system with Human Machine Interface (HMI) for the monitoring and routing for movements within the Manual Area of the MSF housed in the OCC Yard Control Workstation

e. Systems for train control when the Driverless ATC system has failed.

f. All subsystems shall be designed and supplied for trains to meet the line capacity and shall be easily upgradeable. The first project shall accommodate incremental increases in capacity (without modification to the system elements) to accommodate the complete project capacity. This includes the design of temporary terminals that later are retired with each subsequent line expansion. The ATC subsystem shall be modular and configured to facilitate expansion to ultimate capacity and the full HHCTCP system by adding ATC equipment and revising software. Expansion shall be implemented by adding ATC equipment without major interruption of the ATC system in revenue operation.

g. The ATC system shall function as a Command and Control Network comprised of integrated systems for continuous vehicle positioning and tracking and communications of control commands with associated supervisory information between OCC, wayside facilities, and vehicle.

h. Vehicle on-board systems shall be capable of monitoring and communicating train data from the train to wayside control equipment and then subsequently onto the OCC. This same system shall be capable of receiving and decoding information from wayside control equipment.

3. For normal operation, the system is controlled from a control center as follows:

a. At the MSF, an OCC located in Operations & Servicing Building that controls the mainline, covering all train movements and access to and from the MSF. The OCC combines the ATS of the Signaling and Communications systems, plus the Electrification system control facility, and warning and protection systems. The ATS remotely controls all the mainline interlockings via a data transmission system, using duplicated links for availability.

b. The ATC system shall consist of equipment located in the OCC, along the wayside, in station areas, and on-board the vehicles. The actual distribution of such equipment shall depend upon the specific system installed.

c. Not Used.

d. The Train Control/Communications Room (TCCR) locations are provided to enable the Mainline Train Control system to function uninterrupted while being controlled locally whenever OCC is not available.

4. If the selected design requires, the train detection system can be a combination of axle counters or track circuits on the mainline and the MSF.
5. Electronic interlockings are of the distributed type. Wayside equipment is connected to the interlockings by secure multiplexed data links, which are duplicated for availability.

6. A Train Tracker system is provided that keeps track of individual trains and provides information about each train to other systems and to staff.

7. An ARS system enables trains to be routed automatically in an efficient manner with minimal operator intervention, and ensures that delay to trains is minimized when perturbation to the timetable occurs.

8. Driverless ATC is used on the mainline to safely control the train’s speed. Moves between MSF leads and the mainline (and vice versa) are also controlled by the Driverless ATC system. The Automatic areas include the ready/layover track(s), the cleaning and Train Wash tracks and Vehicle Storage tracks, the yard mainline lead tracks, and all lead tracks to these areas. Please refer to attached drawings SCY-align240-tw-OPT A-E F-A.pdf and SCY-align240-tw-OPT A-E F-A-COLOR.pdf for current MSF layout information. Vehicles from the Automatic areas shall be able to directly access the mainline. Vehicles entering the MSF from the mainline shall be able to be automatically routed to/through the Automatic areas. The Driverless ATC system provides a complete speed supervision system, providing the vehicle with the permitted speed profile. To cope with failures, a degraded mode of operation is available, with wayside route indications for use at low speed (10 mph). In event of attended train operations, a rescue speed (30 mph) is available with protection from the Train Control system.

9. An ATO subsystem is provided to regulate the train’s speed performance, perform station stopping, and door operation.

10. Wayside signaling is provided for interlockings and tracks controlled by the Yard Control Workstation at the OCC.

11. A track safety system is provided. This system interfaces with the ATP subsystem to stop or slow down trains where staff is working in the track safety zone.

12. Wayside warning systems are provided for detection and warning of dangerous environmental and man-made conditions. The former include “disaster” systems for detecting earthquakes and man-made incidents such as road vehicles intruding on the transit line. Some warning systems are advisory, and some interface directly with the ATP subsystem to stop or slow down trains.

13. The ATC system is segregated into vital and non-vital systems. Vital systems are comprises of, but not limited to, interlockings, train detection systems, and Driverless ATP systems in accordance with internationally recognized and accepted signaling principles and practice for safety systems. Non-vital systems comprise controllers’ interfaces, ARS systems, management and passenger information systems, and non-vital data transmission systems.

B. Section Includes:

1. Interlocking Requirements
2. Wayside Equipment Requirements
3. Warning Systems
4. Control Centers General
5. Operations Control Center
6. Not Used
7. Train Control/Communications Rooms (TCCR)
8. Driverless Automatic Train Control System
9. Track Protection Systems
10. Alterability

C. Related Sections:
   1. Section 27 90 00 – Operations Control Center Ancillary Equipment

1.02 PRICE AND PAYMENT PROCEDURES

A. Measurement and payment for the Section is defined elsewhere herein.

1.03 CODES, STANDARDS, AND RECOMMENDED PRACTICES

A. The governing version of the listed documents shall be the latest as adopted and administered by the City.

B. Institute of Electrical and Electronics Engineers (IEEE):
   1. IEEE 802.3 Ethernet network standard
   2. IEEE 802.11 Wireless network standard
   5. IEEE 1474.3-2008 IEEE Recommended Practice for Communications-Based Train Control (CBTC) System Design and Functional Allocations

C. American Society of Civil Engineers (ASCE):
   1. ASCE 21.2 Automated People Mover Standards – Part 2
   2. ASCE 21-05 Automated People Mover Standards – Part 1

D. European Committee for Electrotechnical Standardization (CENELEC):
   1. EN 50126-1999 Railway applications – The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS)
2. EN 50128-2001 Railway applications – Communication, signaling and processing systems – Software for railway control and protection systems

3. EN 50129-2003 Railway applications – Communication, signaling and processing systems – Safety related electronic systems for signaling

4. EN 50155-2001 Railway applications – Electronic equipment used on rolling stock

5. EN 50121-2000 Railway applications – Electromagnetic compatibility

6. EN 50124-2001 Railway applications – Insulation coordination

7. EN 50159-2001 Railway applications – Communication, signaling and processing systems – Safety-related communication in transmission systems

1.04 SCOPE OF WORK

A. General:

1. Unless specifically excluded in these Train Control system requirements, provide everything necessary whether specifically mentioned in these Train Control system requirements or not, to ensure the successful implementation, safe, and proper operation of the Train Control system in the specified environment.

2. Submit a copy of the quality control and assurance program as stated elsewhere in this Contract.

3. All equipment and systems provided by the Contractor are tried and tested in service. Submit a comprehensive service history as evidence of the applicability for this entire System, including future extensions, for City approval.

B. Scope:

1. Undertake, produce, operate, and maintain everything necessary for the Train Control system including, but not limited to the following:
   a. Design
   b. System Integration
   c. All aspects of System Assurance
   d. Manufacturing
   e. Supply of material and equipment
   f. Construction and installation
   g. Testing and commissioning
   h. Recommended periodic tests and inspections
   i. On-site technical support during the Warranty Period
   j. Operational and technical training
   k. A list (with prices) of associated spares and special consumables
   l. Special Tools and other maintenance equipment
m. Technical Documentation including, but not limited to:
   1) Design Manuals
   2) Installation Manuals
   3) Operating Manuals
   4) Maintenance Manuals

n. Off-line systems

o. Measurement and Diagnostic Test Equipment

p. OCC, Station and Yard Control Workstation equipment, furniture, and a definition of the recommended architectural finishes such as décor and lighting

2. Provide all data communication systems (including cables) required for transmission of all, both vital and non-vital, Train Control data between each interlocking and its associated wayside equipment.

3. Correctly interface and integrate all equipment and installations with the infrastructure, and all such equipment and installations shall be capable of performing properly and reliably in the Honolulu environment.

4. Automatic operation of the remaining areas of the Operation Service Building (OSB) tracks is at the Core System Contractor’s option and costs.

C. Exclusions: These Train Control system requirements exclude the following:

   1. Operations & Servicing Building
   2. Maintenance of Way Building
   3. Main duct banks and cableways
   4. Seismometer and High Wind installation rooms
   5. Track circuit insulated joints (IJs)
   6. Procurement and installation of switch machines (the mechanical adjustments and electrical installation/adjustments shall be performed)

D. Consequential Work of Extensions to the system:

   1. The work includes many stages within this contract and beyond for the full system.
   2. Where the system’s extension work has an impact on revenue service, assess this impact in the design to minimize disruption of revenue service.

1.05 GENERAL REQUIREMENTS

A. Train Control Requirements:

   1. The Train Control system shall facilitate the safe operation of all rail vehicle movements on the mainline, transfer/ready tracks, and yard tracks of the MSF. It shall incorporate facilities to include the following:
      a. Protect movements from other trains and rail vehicles
      b. Protect movements from Train Control system failures
      c. Protect movements from certain hazard conditions defined elsewhere
d. Provide protection systems for staff from trains and provide facilities whereby movements are either inhibited or subjected to a restriction in maximum speed in the presence of staff

e. Detect some infrastructure conditions

f. Meet the operational journey time objectives as detailed in the Operation Plan

g. Provide Program Stopping at all mainline stations

h. Ensure reliability and availability as specified by being constructed with a fault tolerant architecture based on the use of backup and stand-by alternatives

i. Assist maintenance staff in maintaining it by diagnosing failures to minimize time to rectification

2. Numbering System: Submit in detail a numbering system to uniquely identify all wayside, room, and vehicle equipment.

3. De-energized Contact Rail Sections and Gaps in the contact rail:
   a. Analyze and design the Train Control system and locate a stopping point to ensure that no train will ever be required to stop within a double crossover near an isolated portion of the Contact Rail system contact rail due to trackwork constraints as in turnouts or crossovers.
   b. Analyze and design the Train Control system to ensure that no train travels into a section of de-energized contact rail trackage recognized by the Electrification system. Once the trains are stopped by full service braking, the ATS subsystem shall present recovery scenarios to the OCC controller.
   c. Submit in detail the criteria applied and assumptions made in satisfying these requirements.

4. Train Control Headway:
   Design the Train Control system to meet the Operation Plan in accordance with Technical Provisions Section 3.4.2.2.
   a. The Train Control Headway for trains running in the reverse direction shall be stated by the Contractor.
   b. Provide detailed train graphs (or equivalent computer simulation evidence) demonstrating how the proposed Train Control system arrangement will meet the planned requirements and highlighting the capacity available to recover from perturbations.
   c. If fixed block technology is chosen by the Contractor; design, install, and test a block design showing that the boundaries and all speed commands maintain safe braking distance for normal and reverse running and civil restrictions. Provide a minimum design headway in accordance with Technical Provisions Section 3.4.2.2 for operations in both directions on each track. Take into account all speed restriction areas, station locations, interlocking operations, traction power interfaces, and energy saving. Submit the following for approval by the City for review:
      1) Written explanation and detailed flowcharts of the block design simulation programs for the review
      2) Control line charts for normal and reverse traffic direction, track plans, and the cable plans
3) Computerized simulation runs showing runtime and headway’s both normal and reverse direction
4) Safe braking distance for each block boundary with each maximum authorized speed and all lower speed limits concurrently with the control lines

5. Line Speed: The maximum permissible Line Speed is defined in Technical Provision TP-03, “O&M Performance Requirements”, although some sections of line will have a restricted lower maximum speeds due to civil and passenger station restrictions. If the consist is performing a skip stop, the maximum permissible speed through the entire length of a platform for the entire consist is 30 mph. The maximum crossover speed is 20 mph.

6. Train Control Arrangements:
   a. The normal method of train control on the mainline and automated areas in the MSF shall be by Driverless ATC.
   b. The Train Control arrangements shall be designed and constructed to achieve an Operational Headway sufficient to achieve parameters of the Operation Plan of the complete system, not the first project.
   c. The Driverless ATC system shall be designed such that movements can be made in either direction over all sections of the mainline. This is known as Bi-Directional Train Control.
   d. Throughout any section of the mainline, the Train Control system shall be capable of changing to reverse direction operation on the adjacent track with ATP, ATS and OCC oversight. This arrangement shall therefore permit overtaking movements.
   e. The nominated normal direction of running shall be the right-hand track when traveling in the facing direction.
   f. Train Control shall permit running at the maximum Line Speed in both the normal and reverse directions.
   g. Transfer to and from the reverse direction track shall be achieved by protected moves over crossovers connecting the tracks, normally in a facing direction. However, it shall be possible to make “turn back” moves under full Driverless ATC.
   h. Provide a detailed proposed Train Control arrangement that will meet these requirements and highlighting the capacity available to perform different scenarios to single tracking and the rescue of stranded vehicles.

7. Electrical Immunity and Grounding (for the outline of details, refer to Design Criteria Chapter 25 – Safety and Security):
   a. Train Control Equipment:
      1) Train Control equipment shall be immune to the operation of the City’s Contact Rail system of the 750-Volts Direct Current nominal Electrification system for both peak load and fault conditions such that it:
         a) Does not induce Train Control failures, faults, or operationally unsafe conditions
         b) Is safe for maintenance staff to work on
      2) Submit the maximum induced 60-Hz voltages appearing in the Train Control system under both normal operating conditions and fault
conditions, and shall adopt a Relevant Standard that is met by these voltages, taking into account the fault clearance time.

3) All signaling equipment and systems shall operate normally and reliably in the presence of electrical interference from the Contact Rail system and with and without trains running on the line. Utilities transmission lines crossing or running adjacent to the system shall not have a detrimental effect on the train control equipment.

4) Submit detail levels of such interference that may be expected to appear from external and system sources in the Train Control system under worst-case conditions together with supporting evidence, calculations, and solutions.

5) Immunity and protection methods proposed for all equipment that is part of the Train Control system shall be submitted by the Contractor.

6) Immunity and protection measures shall be designed for worst-case fault conditions. They shall be applied uniformly to all signaling wayside systems, irrespective of the location of those systems in relation to substations.

7) Details of all signaling equipment immunity to 60-Hz voltages, its harmonics, and the effect of electrical interference from the train as described earlier in this Section shall be given by the Contractor for both traction peak load and fault conditions. The information shall include the levels of interference at which any Failures occur.

b. Wayside Circuits and Cabling:

1) Vital Train Control circuits shall be ground free, and a single ground fault shall not affect the integrity of the Train Control system.

2) Submit a description of how it will detect and correct a single ground fault before a further fault could endanger the integrity of the Train Control system.

3) Submit its preliminary design for ground leakage detection that shall be both simple and effective for monitoring correct operation.

4) For personnel safety, ensure that any one building, room, or apparatus case is only grounded to a single main earth system (except as in Article 1.05A.7.b.5 herein), to eliminate potential hazards caused by different ground potentials.

5) The only acceptable additional ground will be a test ground for ground leakage requirements. The ground studs for such a ground shall be shrouded and insulated from the mounting and labeled: “WARNING – INDEPENDENT LEAKAGE TEST GROUND.”

6) Submit its preliminary design for the grounding and bonding of the Train Control system and equipment to ensure:
   a) The safety of staff and others
   b) The adequate protection of the equipment against system faults including those associated with the Contact Rail system
   c) The safe operation and integrity of the equipment

7) Provide outline arrangement drawings that illustrate the location of wayside apparatus cases. Submit proposals for ensuring the safety of staff
from Touch Potentials. Describe the need for special maintenance procedures or warning notices.

8) Submit the design standard and details of such measures proposed in respect of, but not limited to, the following:
   a) Train Control Equipment Rooms
   b) Train Control Operational Rooms
   c) Wayside apparatus cases
   d) Wayside structures and equipment
   e) Track mounted equipment
   f) Cabling
   g) Vehicle mounted equipment

9) Submit preliminary design for the provision of ground leakage detection especially in respect of the following:
   a) Bus bars supplying vital Train Control system equipment
   b) Bus bars supplying switch-operating mechanisms

10) These submittals shall include, with full justification, the maximum permitted ground discharge current and time to ground from the bus bars.

8. Control and Indication Processors and/or Data Transmission System:
   a. The key requirements of the non-vital data transmission system are that it shall be transparent to the Train Control system, and the controllers shall experience no perceivable delay in system response. There shall be no characteristics of the control and indication processors and/or data transmission system that manifest the operation of the signaling. Refer to Table 27 20.01-1 of Section 27 20.01 – Communications Transmission System, for the committed information rate for Train Control.
   b. To operate in a signaling environment, the system shall be able to respond to multiple input changes taking place simultaneously.
   c. Certain inputs may be of a push button type, which will be fleeting in nature and will require sequential operation. The system shall be capable of registering such inputs and ensuring they are transmitted to the remote locations in the correct order.
   d. Comprehensive monitoring and diagnostic facilities shall be provided to enable speedy and logical diagnosis of system faults.
   e. Failure of diagnostic facilities shall not affect proper working of the operational system.
   f. System failures or extraction/insertion of system PC cards shall result in the freezing of affected outputs. Such outputs shall remain frozen until correct operation is restored and outputs are able to faithfully reflect the status of inputs. Spurious operation of outputs is not acceptable.
   g. Submit details and evidence to demonstrate how the system proposed meets these requirements from the input and output perspective.
   h. The system shall incorporate diagnostic facilities to enable the maintainer to monitor output bits and output bit groups.
   i. Comprehensive alarm and indication facilities shall be provided for data transmission systems. Such facilities shall alert OCC Train Controllers and
maintenance staff to the status of data transmission systems including the failure of main or standby systems.

9. Equipment Security:
   a. Access to external signaling and communication equipment shall be restricted. All such equipment shall be capable of being secured by lock or padlock. Responsible for provision of all such locking facilities. Two types of padlock are required as follows:
      1) Type A: To be used to secure signaling equipment and apparatus and signaling apparatus cases, equipment housings, and rooms
      2) Type B: To be used to secure operations rooms and operational access to signaling equipment where authorized
   b. Two types of keys shall be provided as follows:
      1) Type AB: To be capable of unlocking both type A and type B padlocks, for issue to signaling maintenance and City staff
      2) Type B: To be capable of unlocking type B padlocks only, for issue to authorized operations staff
   c. Lock and padlock quantities are the responsibility of the Contractor, and shall be agreed by the City.
   d. Submit details regarding the robustness of proposed lock mechanisms. Padlocks shall be maintenance free items.
   e. Submit an option for additional padlocks, locks, and keys in quantities of one hundred.

10. Equipment Layouts and Access:
    a. All Equipment, both ATC and Communications, shall be laid out in Equipment Rooms and other housings in a logical and consistent manner. The spacing between items of equipment, equipment modules, cable terminations, and plugs/sockets shall be such as to allow easy access for maintenance purposes. Submit typical sketches clearly indicating such features including, but not limited to, the following:
       1) Room layouts
       2) Housing layouts
       3) Equipment spacing
       4) Module spacing
       5) Plug/socket arrangements
       6) Working clearances
       7) Local Control panels or workstations
    b. Arrangements for equipment entry and access shall be detailed by the Contractor.
    c. Adequate clearance shall be provided between adjacent plug/socket arrangements to ensure easy access for attaching/detaching.
    d. There shall be no trailing leads other than coiled connections to keyboards.
11. Materials, Protection, and Finishes: Materials, protection, and finishes shall be suitable for the environment. Take account of such issues including, but not limited to, the following:
   a. Whole life durability.
   b. Resistance to atmospheric conditions, including, but not limited to, chemicals, salt, moisture, water, solar, and pollutants. To avoid electrical damage inside signaling cabinets and boxes due to floods or humidity, the wayside devices shall be waterproof.
   c. Dustproof.
   d. Resistance to accidental damage.
   e. Resistance to vandalism.
   f. Color schemes.
   g. Finishes.
   h. Maintenance of appearance and cleaning.
   i. Artwork.
   j. Staff safety, sharp metalwork, grounding, and bonding.
   k. Disaster damage.
   l. In stations, cables shall conform to all applicable standards. Cables shall be rodent damage protected, halogen free type, and fire retardant. When necessary, the cable shall be protected from the effects of solar radiation.

12. Spare Capacity:
   a. A minimum of 10 percent increase in signaling and associated operational facilities shall be allowed for to take account of possible modifications and alterations.
   b. This provision of 10 percent spare capacity is based upon equipment quantities that include those items of equipment required for the expansion of the system.
   c. Spare capacity shall be included in systems and equipment to facilitate future changes to the transit network. The precise nature of such spare capacity will be dependent on the types of systems and equipment supplied; submit details of how spare capacity will be accommodated.
   d. It is anticipated that spare capacity shall be included in, but not limited to, the following:
      1) Cabling, cable troughs and cable trays including 10 percent spare cores with a minimum of two spares
      2) Control rooms (the OCC and TCCRs) having space for 10 percent additional equipment accommodation
      3) Data transmission systems with design capability to transmit additional 10 percent data
      4) Track to train data systems with design capability to define additional 10 percent code and space to accommodate the transmitter and receiver
      5) Power supplies with 10 percent additional capacity based on full load.
      6) Interlocking processors and other processor-based systems with design capability to have additional 10 percent capacity.
7) Equipment housings with additional 10 percent space  
8) Equipment rooms with additional 10 percent space  
9) Display panels with design capability to show additional 10 percent data

13. Design Life: Supply high quality equipment and systems with a 35 years life expectancy, and shall install them in a manner that optimizes the life expectancy of the whole Train Control system, considering replacement of equipment or modules in the future when such equipment may become obsolete during the life expectancy period.

14. Availability:
   a. Submit a statement of the techniques employed to achieve high availability and fault tolerance.
   b. Demonstrate that the overall reliability and availability of the Train Control system will be consistent with the reliability and availability requirements for the required train service.
   c. For the whole operational Train Control system provide the statistics required below together with the methods of calculation, worked examples and a comprehensive list of assumptions made in reaching the figures quoted.
   d. For each of the classifications of loss of availability listed below state:
      1) The nature of facilities lost in the particular systems proposed:  
      2) Mean Time Between Failures  
      3) Mean Time to Repair, based on the maintenance and fault repair regime proposed
   e. Wayside Train Control Functions:
      1) In this context, wayside signaling functions are those functions specifically related to the signaled movement of trains and therefore exclusive of ancillary systems (e.g. ARS, Automatic Line Algorithm, Train Tracker (TT) system) and Driverless ATC on-board equipment.
      2) The different classes of availability for wayside signaling functions are listed below:
         a) Class 1: Loss of all signaling functions by the OCC Train Controller, irrespective of whether or not this is due to failure of functions or loss of communications. The calculation shall take into account the provision of full, physical diverse routes for the communication links and the telecommunications availabilities requested.
         b) Class 2: Loss of all signaling functions throughout one or more, but not all, interlocking areas.
         c) Class 3: Loss of signaling functions such that significant delay is incurred in either direction. This class shall be exclusive of the previous classes. Significant delay shall be defined as the loss of signaling for two or more consecutive Block Sections between stations.
         d) Class 4: Loss of signaling functions involving the loss of facilities in less than two consecutive Block Sections, which cause delays in excess of 3 minutes per train.
c) Class 5: Loss of individual signaling controls and indications, which while inconvenient to the Train Controller, do not degrade operations in any significant manner.

f. Vehicle Signaling and Train Control Functions:
   1) This Section refers specifically to on-board equipment and systems and assumes that maintenance will be undertaken in accordance with traction and rolling stock maintenance and servicing requirements.
   2) The different classes of availability for on board signaling and train control functions are listed below:
      a) Class 1: Total loss of signaling and train control facilities on a Consist, which results in the need for isolation of the Driverless ATC and the use of manual control panel by the operator.
      b) Class 2: Partial loss of signaling and train control facilities such that operation can be continued in degraded mode.
      c) Class 3: Loss of facilities only causing a minimal amount of degraded operation and not covered by the preceding classes.

   g. Ancillary Train Control Systems:
      1) This Section shall apply separately to each identifiable Train Control system not incorporated in the above (e.g. ARS, Automatic Line Algorithm, TT system, etc). Each system shall be named and its boundaries clearly defined.
      2) The different classes of availability for ancillary signaling functions are listed below:
         a) Class 1: Total unavailability of system named.
         b) Class 2: Loss of facilities such that the named system will only operate in a degraded fashion causing the Train Controller to have to take actions for the majority of trains moving within his control area.
         c) Class 3: Loss of facilities only causing a minimal amount of degraded operation and not covered by the preceding classes.

15. System Architecture:
   a. High availability fault tolerant systems shall be provided.
   b. System architecture multiplicity shall generally be employed with fully updated standby systems and automatic changeover facilities.
   c. Submit a block diagram that details interrelationships between all systems and subsystems. Multiplication of systems, subsystems, and communications links shall be detailed.
   d. Submit a sensitivity analysis of multiplicated systems demonstrating the value of the redundancy.
   e. Multiplicity-for-availability systems shall not require action by members of the staff to change from an on-line system to a standby system.
   f. Automatic changeover of systems shall have no effect on the status of wayside and Driverless ATC functions. Functions, such as wayside signals/indicators, switches, on-board speed data etc, shall be unaffected by automatic changeover of systems.
g. Indications shall be unaffected by automatic changeover of systems such that changeover shall be imperceptible to the Train Controllers or other controllers except for the alarm relating to that changeover.

h. Submit full details of the effect upon the Train Control system during changeover between redundant facilities furnished for availability purposes.

i. State the duration of the changeover period; the system taking charge shall have completed full acquisition of all current data prior to being defined as having taken charge.

j. Off-line systems shall be continuously monitored and semi-urgent alarms given immediately on failure of such systems.

1.06 ENVIRONMENTAL REQUIREMENTS

A. All train control equipment shall adhere to the standards herein and the following:

1. Guideway Mounted Electronic Equipment:
   a. Temperature Requirements:
      1) Operating Temperature Range: 32 degrees Fahrenheit to 131 degrees Fahrenheit
      2) Storage Temperature Range: -4 degrees Fahrenheit to 131 degrees Fahrenheit
   b. Relative Humidity Requirements
      1) Operating Humidity Range: 93 percent at 104 degrees Fahrenheit non-condensing

2. Guideway and TCCR Equipment:
   a. Temperature Requirements:
      1) Operating Temperature Range: 14 degrees Fahrenheit to 131 degrees Fahrenheit
      2) Storage Temperature Range: -40 degrees Fahrenheit to 158 degrees Fahrenheit
   b. Relative Humidity
      1) Operating Humidity Range: 95 percent at 131 degrees Fahrenheit non-condensing

3. Vehicle Mounted Equipment:
   a. Temperature Requirements:
      1) Operating Temperature Range: -4 degrees Fahrenheit to 131 degrees Fahrenheit
   b. Relative Humidity:
      1) Operating Humidity Range: 25 percent to 95 percent over the entire temperature range

PART 2 – PRODUCTS

2.01 INTERLOCKING REQUIREMENTS

A. General Requirements for Interlockings:
1. Interlocking processors shall be electronic, and shall be distributed. Interlocking processors for signaling shall be located near the interlocking or in a TCCR.

2. The interlockings shall apply the signaling principles stated in this Section.

3. In order to minimize wayside cabling, multiplexing of interlocking control and indication data between wayside and interlocking control point shall be adopted where applicable.

4. Where multiplexed data links are used for transmission of vital signaling data, detail the precautions included for maintenance of the integrity of the vital information. As a minimum, these shall include physically diverse routing of redundant transmission paths; the minimum level of diversity shall be the use of cable routes separated by at least two tracks.

5. Provide a PC-based event recording system of all the processes of the interlocking with a user-friendly human-machine interface. The system memory shall be capable of storing a minimum of 72 hours of activity. This information shall be available for off-site analysis.

6. Submit a full description of the interlocking system proposed together with justification for the type chosen. In this description, include the required signal aspects for the mainline and MSF interlockings justifying the need or lack of for safe train operations.

B. Train Control Principles: Submit in detail the signaling principles employed in the proposed interlocking system. However, where any of the following are at variance with the equivalent in the principles proposed by the Contractor, these principles herein shall take precedence. Advise the City if this requirement is in conflict with the requirement to use a proven system.

1. Conflicting Routes: Once a route has been established, it shall not be possible to set conflicting routes.

2. Traffic Locking: Traffic Locking shall be established to confirm during normal operations for the Driverless ATC system that conflicting routes are prevented between adjacent interlockings. Provide a full description of this capability and submit full details of precautions taken to ensure that failure of track circuits, axle counters, or power supplies do not cause erroneous release of Traffic Locking.

3. Approach Locking:
   a. Approach Locking shall be applied to all wayside signaling and the Driverless ATC system on the mainline and transfer/ready tracks. For MSF tracks, time locking shall be provided where train detection is not provided in approach to the signal. Such locking shall be effected on clearance of signals to a proceed aspect (or provision of a proceed indication by the Driverless ATC system), and shall be released under one of the following conditions:
      1) A train has been proved to have passed the signal (or Stopping Point) and entered the route.
      2) The signal (or proceed indication) has been replaced to stop for a sufficient length of time to ensure that approaching trains have not entered the approach sections (such that as a result of change of the proceed indication to stop, the train shall not receive a more restrictive indication), has
stopped safely at the Stopping Point, or has passed the Stopping Point and engaged Route Locking.

3) In Driverless ATC areas, the train has been brought to a stand at the Stopping Point with the associated indication at stop.

4) In Driverless ATC areas, the approach sections are clear to a point such that as a result of change of the proceed indication to stop; no approaching train shall receive a more restrictive indication.

b. Submit timing values for features and together with evidence that such timing values are sufficient for the purpose.

c. Submit details of precautions taken to ensure that track circuit or axle counter failure does not cause erroneous release of Approach Locking.

4. Route Locking:

a. Route Locking shall be effective over the whole of the route, from entrance point to exit signal/stopping.

b. Release of Route Locking shall be subject to release of Approach Locking, together with clearance of track circuits or axle counter sections in the route.

c. Route Locking shall be released progressively behind a train movement as the train proceeds through the route.

d. Routes shall be normalized automatically by the passage of trains: route normalization shall not require action by the Train Controller.

e. Where opposing Permissive Movements are required, arrangements shall be made to release Route Locking after the first train movement has traversed the route.

f. Submit full details of precautions taken to ensure that failure of track circuits, axle counters, or power supplies do not cause erroneous release of Route Locking.

5. Switch Locking:

a. Switches shall be locked either normal or reverse as appropriate by:

1) Routes set over them, including sectional routes held prior to release by the train as it passes through the route

2) Approach Locking

3) Activation of the locking for an individual switch in the dual operation of the switches to prevent conflicting routing

4) Occupation of the track circuit or axle counter section, or any of the track circuits or axle counter sections in the case of a crossover or other multi-ended set of switches, wherein the switches lie

5) Preconditioning prevention being effective

6. Preconditioning prevention:

a. Calls to set routes or move switches shall only be effective if such routes or switches are available and free to move at the time the call is made. It shall be necessary to remove such calls and re-apply them once the routes or switches become available and free to move.

b. Calls applied to set routes or move switches that are not available or free to move shall have no effect whatsoever.
7. Proceed Indication: In addition to the route being established and locked, for a proceed indication to be given, the following are required to be proved:
   a. All switches in the line of route shall be set, locked and detected in the position required
   b. All track circuits and axle counter sections in the line of route shall be clear for Main and Crossover Routes
   c. Specified track circuits or axle counter sections in the line of route shall be clear or occupied for a period of time for Call-on Routes
   d. All Stopping Point indications that allow conflicting moves shall be proved to be at stop
   e. Traffic Locking, Route Locking and Approach Locking shall be proved to be effective

8. Restoration of Proceed Indication (Fleeting):
   a. Restoration of a proceed indication from stop shall normally be effected on passage of a train past the associated Stopping Point.
   b. For controlled routes, such as at terminals and turnouts, once a proceed indication has been restored to stop it shall not be possible to give another proceed indication except by action of the Train Controller or ARS system.

9. Overrun Protection:
   a. Overrun Protection shall be provided to protect against trains overrunning Stopping Points owing to variations in braking performance and/or error. Such protection shall normally comprise a clear section of track beyond the Stopping Point into which a train may be safely brought to a stop. In the event of a train overrunning a Stopping Point, emergency braking shall be applied automatically to bring the train to a stop within the Safety Margin. If the Stopping Point is at an interlocking, an overrun shall cause proceed indications from the opposite direction on that track, including routes lined from adjacent interlockings to that track, to be replaced by stop indications.
   b. Where appropriate, Route Locking shall extend into such Safety Margins and shall be subject to release when the train has been proved to be at a stop at the associated Stopping Point.
   c. Submit full design details of Safety Margins together with supporting train control and stopping calculations.

10. Reversible Moves using Traffic Locking: Moves in the reverse of the normal direction shall only be initiated by OCC except for crossover moves at terminal location. On any change of direction, the whole section shall be proved clear of trains or vehicles, and without opposing routes at the adjacent interlocking with Stopping Point indications at stop.

11. Wayside Signals/Indicators: Main aspects shall step down (to a more restrictive aspect) on lamp failure.

2.02 WAYSIDE EQUIPMENT REQUIREMENTS

A. General:
1. Wayside equipment shall be positioned on the wayside in full conformity with the structure gauge taking account of the Line Speed defined in Technical Provision TP-03, “O&M Performance Requirements”.

2. Equipment shall be positioned to minimize danger to maintenance staff from the transit operations and Contact Rail system.

3. Submit wayside space requirements and foundation, mounting and positioning details for each type of wayside equipment and housing on both mainline and MSF tracks. In doing so, address, as a minimum, the chainage and elevation of the following:
   a. Retaining walls
   b. Embankments
   c. Bridges and Overpasses
   d. Ballast mounting (horizontal and vertical)
   e. Direct Fixation mounting (horizontal and vertical)
   f. Railings

4. Wayside equipment shall be fit for its purpose and subject to minimal maintenance. Where periodic maintenance is required, this shall require minimal interference of the Train operations.

5. The following features shall be applicable to on-track equipment:
   a. It shall be robust enough to withstand, or be suitably protected from, impact by trailing couplings or other train dragging objects
   b. It shall be strong enough to support the weight of staff walking along the track
   c. The upper surface shall be of the non-slip type
   d. It shall withstand the full range of vibrations experienced at its location

6. For each piece of wayside equipment, submit a full description including technical details, physical arrangements, and operating characteristics.

B. Wayside Signals/Indicators:

1. Wayside signals/Indicators shall generally be provided throughout MSF areas for safe moves performed by operators.

2. Wayside signals/Indicators shall be fitted with unique identity plates clearly legible to operators when their train has stopped at the signal.

3. Where wayside signals are provided, submit the following information:
   a. Detailed sketches establishing that convenient sighting for drivers is available for each different structure. Sighting shall be such that the operator has a clear view of any aspect and indication for at least 10 seconds at the maximum speed at which the operator would be required to see the signal aspect. The placement of signals shall be outside the clearance envelope of the vehicle.
   b. Sketches of all profiles detailing height and offset of the main aspect from the nearest rail, rail level, separation of aspects, and all possible additional indications.

C. Wayside Marker Boards:
1. Wayside marker boards shall be installed throughout the automated areas for facilitating backup train operations including certain of the following:
   b. Train location under signaling failure conditions.
   c. Control of movement of trains from marker to marker under signaling failure conditions. Wayside signals may be provided for this purpose.

2. Should the Contractor offer a system that does not use wayside marker boards, submit an explanation of how the criteria stated in this Section will be satisfied.

3. Where provided, wayside marker boards shall:
   a. Carry unique identity plates, which are clearly legible to drivers brought to a stand at the board
   b. Be reflectorized such that operators may bring trains to a stand at a board on sight from a speed of 30 mph.

D. Switch Machines for Interlockings:

1. Switch machines will be supplied by others and will be suitable for the operation of the range of interlockings to be used. The Contractor will receive details of all essential characteristics of the switches and shall manage the interface with the MSF DB Contractor. There are two quite separate environments where switch machines are required. First, on the mainline where switches shall have movements over them at a maximum speed defined in Technical Provision TP-03, “O&M Performance Requirements” in the normal position. Secondly, in MSF areas where interlockings shall be used and the maximum speed shall not be greater than 10 mph.

2. For switch machines that are proposed for use on the mainline, clear concurrence shall be presented to demonstrate their suitability at the proposed Line Speed.

3. The Contractor will receive information of switch machines proposed. The full description will include:
   a. Power supply required, including solar or alternative sources
   b. Power consumed/load data
   c. Time of operation/load data
   d. Operating voltage and current
   e. Open switch tolerance
   f. Stroke
   g. Protection against overload of motor
   h. Throwbar thrust generated

4. Detection contacts will be separate and independent of mechanisms driving the switches. Detection contacts will only be made when switches are set and locked.

5. All mainline switches’ mechanisms shall be physically locked with locks provided.

6. The direction of working of the mechanism shall be capable of being changed at any part of its stroke.

7. Means shall be provided to prevent overloading of the motor in the event that movement of the switches is prevented by an obstruction.
8. With reference to the MSF DB Contractor, submit recommendations for closed switch tolerances in respect of operation of detection and lock mechanisms.

9. All necessary mechanical fittings associated with the switch mechanism will be provided. Fittings will be adjustable and, where required for a track-circuited area, will be insulated. Full details of fittings will be submitted to the Contractor and will include, but not be limited to, the following:
   a. Operating drive rods
   b. Lock rods
   c. Detection rods
   d. All necessary cranks, lugs, screws, bolts, washers, and ancillary equipment.

10. Either in-service statistics or the results of field service trials of reliability and availability will be submitted to the Contractor. Where these are not in a similar situation to this proposal a clearly defined method of extrapolation shall be developed and the extrapolated figures included. All assumptions and calculations shall be submitted.

11. Failure rates against time in service, and failure rates against number of operations, will be submitted to the Contractor.

12. Switch machines will be such that they may be operated manually by the hand throw mechanism and by the use of a crank handle, or similar device. One crank handle or other device per mechanism will be provided and able to be secured and padlocked to the machine housing. For staff safety there will be a motor cutout contact that will automatically disconnect the motor power supply on insertion of the crank handle, or equivalent, to permit manual operation. The power supply circuit will not be capable of re-connection until the crank handle or equivalent has been withdrawn from the machine and manually reset.

13. Insertion of the crank handle or other device will not interfere with the switch detection, and shall not foul the structure gauge or vehicle envelope.

14. Where a Switch Machine employs multiple sets of detection, the inclusion of no more than two elements of detection in one detection circuit together with the use of several circuits combined to form the detection of the switch is encouraged. This arrangement aids maintenance by minimizing exposure of staff to the transit line.

15. Switch machines will be designed with heavy duty internal switching to break the power supply to the motor at the completion of the stroke. The controlling contactors will only break the operating current when the machine is on overload.

16. Switch machines for the MSF will be trailable. Point Detection will be either internal or external to the machine.

17. Where more than one switch may be moved by a single command from the interlocking, state if the staggering of starting of switch machines is required to avoid excessive momentary current demands and submit details as to how it will be controlled.
   a. Independent Detection: The separate indication of the detection of each end of a crossover to the Train Controller can assist operation of trains in the degraded mode of switch failure, where detection has failed at one end. This separate indication shall be provided. All signaled movements over the failed switches...
will be inhibited; however, use may be made of this feature in the operational regulations to facilitate the calling of trains over the end that retains detection.

E. Train Detection:

1. Axle counters or track circuits may be used for detecting the presence and absence of trains on mainline, Ready/Layover and MSF interlocking tracks. Otherwise, a detailed proposal of the preferred alternate method for train detection shall be submitted.

2. Submit detailed proposals, including the utilization of impedance bonds, for the use of the rails for train detection and traction return purposes. The compatibility of the use of rails for both purposes shall be clearly demonstrated.

3. Ensure that under no circumstances shall effects of the traction current, including interference currents or transient effects produced by the traction system on the train, cause failure of the train detection systems.

4. Track circuit arrangements that eliminate or minimize the use of IJs, are preferred. If IJs are required, submit the location and electrical and mechanical characteristics of the IJ.

5. Submit other constraints on the system by any of the train detection systems.

6. Train detection systems shall operate reliably for all vehicle types (including maintenance vehicles) and for all modes of vehicle operation. For this purpose, submit detailed provisions, which will be made in the system design, for every type of rail vehicle that the train detection systems are required to detect. These provisions shall include, but are not limited to, the following:
   a. Vehicle overhang beyond outer most axle
   b. Maximum distance between wheelsets within any train or vehicle
   c. Minimum distance between first and last wheelset in any train or vehicle
   d. Wheel profile/rail profile/running surface
   e. Vehicle weight and axle load
   f. Rail surface contamination
   g. Extreme environmental conditions such as heavy rain and local flooding
   h. Traction rail(s) isolation between MSF and mainline

7. The arrangements shall ensure that there is no loss of train detection during the passage of all types of rail vehicles including the shortest vehicles, vehicles with the longest wheelbases, and light vehicles (including rail mounted maintenance vehicles).

8. If there are constraints on vehicles that are required to correctly operate the proposed train detection systems, these shall be clearly defined and submitted by the Contractor.

9. If the Contractor’s design uses jointless track circuits, it shall provide sufficient overlap between track circuits such that vehicle detection is never lost. Submit detail of the provisions that have been made in the system design to ensure safety if this occurs.
10. Track circuits shall use loss of shunt protection within the interlockings and wherever the Contractor’s analysis defines the need.

11. Procedures to be employed for resetting axle counters after failure (including failure of the power supply) shall be submitted. Demonstrate how these procedures ensure that correct operation of the failed axle counter section is proven before indicating that the section is clear.

12. Submit details to demonstrate that no failure can occur as a result of vehicles stopping, moving slowly, or reversing, with a wheel within the detection range of an axle counter.

13. All track circuit bonding and jumpering shall be series bonded where practicable, such that any failure (e.g. a disconnected bond) will not result in any section of the track circuit being unable to detect a train. In case of switch areas, the track circuit configuration should limit the number of IJ.

14. Track circuit bonding shall not rely on jumpers provided for traction purpose to maintain its integrity (i.e. separate distinct bonds and jumpers shall be provided for signaling purposes).

15. Submit values for train (2-car train) shunting for each type of track circuit proposed.

16. Suitable precautions shall be incorporated to protect the Train Control system against irregular operation of track circuits. Full details of such measures shall be submitted by the Contractor.

17. Submit the maximum and minimum length applicable for each type of track circuit and axle counter section proposed.

F. Cable Route:

1. The main and subsidiary cable routes will be furnished by the City. Submit all main cable route requirements including:
   a. Physical capacity
   b. Accessibility
   c. Cross-track crossings
   d. Thermal conductivity requirements
   e. Interference susceptibility from cabling furnished by other users of the same or an adjacent route
   f. Constraints on the use of the route for other services
   g. Cable arrangements compared to the Guideway, MSF, and Station Design Plans

2. Signaling cabling shall not interfere with the operation of other cabling that may be fitted in the same route or in a route adjacent to it. If other than Core system cable is to be fitted in the same route or adjacent route as Core system cable, coordinate with the other disciplines.

3. Submit requirements for subsidiary cable routes to signal rooms and wayside locations and equipment. Responsible for arrangements for the security of cables that exit the main cable route and are routed to wayside equipment (tail cables). Such arrangements shall be rugged and shall protect cables from damage by track
formation or on-track maintenance machines. Submit details of how such security shall be achieved.

G. Locations:

1. A location is the housing for a collection of wayside equipment. It may be one or more apparatus cases. A housing provided by this Contract is envisioned for use to contain the necessary train control equipment. The maximum external height of this housing shall not exceed ten feet in height. Interface with the MSF DB Contractor for the configuration requirements of duct bank and foundation.

2. Submit the requirements necessary for the Guideway and Station contractors to undertake the works necessary to accommodate the location and associated mounting and/or structural members.

3. When possible, ensure that adequate provision is made for installation of apparatus cases in the design of guideway, station, and other civil engineering structures.

4. Apparatus case bases shall be sealed. A case mounted on any platform is prohibited.

5. Apparatus cases shall be fitted with:
   a. A switched lamp (“quickstart” fluorescent or equivalent)
   b. Test points to assist maintenance staff in routine measurements and fault finding procedures
   c. Secure storage for and adequate facilities to permit inspection and use of on-site maintenance documentation
   d. Physically separate accommodation for batteries

H. Train Movement Inhibit system: In the yard, provide a blue signal system whereby staff can inhibit the movement of a train while it is being cleaned and serviced. The system shall be operable only by authorized staff. Indicators shall be illuminated when the system has been activated so that staff knows that it is safe to work on the train and the operator knows that the train cannot be moved.

2.03 WARNING SYSTEMS

A. Platform Fall Detectors:

1. Platform Fall detection shall be provided on all tracks traversed by revenue trains within the platform areas of all stations to detect objects or persons that infringe into the trackway adjacent to the platform. The resultant action includes the stoppage of trains into the station on either both or one tracks depending upon the station’s configuration. The alarm shall cause the ATP subsystem to ensure the stoppage of all trains by braking.

2. A self-check routine shall be carried out automatically by each detector following passage of every train. The results of the self check routine shall be recorded and be available to the Train Controller.

B. Broken Rail Detectors: Double rail track circuits shall be utilized. For testing purposes, the track circuit shall be designed such that the track relay or the device that functions as the track relay shall be in the de-energized position whenever a shunt is connected at any
point across the track rails of the circuit. Suitable shunt resistance shall be proposed by the Core Systems Contractor and shall be subject to review and acceptance by the City.

The track circuit shall operate such that the track relay or the device that functions as the track circuit relay shall be in the de-energized position whenever any of the following conditions exist:

1. A train or vehicle occupies any part of a track circuit including the fouling section of turnouts and crossovers.
2. A rail is broken within the boundary of the track circuit.
3. A switch frog is removed within the boundary of the track circuit.

The track circuits shall be designed to operate in accordance to AREMA C & S Manual 2008 Volume two, Sections 8, Part 8.1.1 and Part 8.6.1

The length of any section of a track circuit shall not be longer than that required to ensure broken rail detection, giving consideration to ballast leakage and the spacing of traction cross bonding. Calculations shall be made and checked by field tests under the most adverse conditions to assure that cross bonding, as installed, does not interfere with broken rail detection.

C. Disaster Warning Systems: For the disaster warning systems listed below, provide and install all sensors and site equipment, and also be responsible for transmission of data, interfacing with the Train Control system including provision and connection of interfacing cables, power supplies and provision of operational interfaces as specified. During the design phase, establish the exact number of systems to be provided; however, the systems and the initial quantities to be supplied are as follows:

1. Earthquake (every 3 mi. with combination of adequate level of sensors): On detection of an earthquake, specific action shall be dependent on the severity of the earthquake. The general principles that shall be enforced by the Train Control system shall be as follows:
   a. Trains approaching a severely affected area shall be stopped
   b. Trains within a severely affected area shall be stopped initially with provision for release by the OCC train controller to 10 mph maximum, to enable them to leave the affected area
   c. Trains within an affected area shall be subjected to 10 mph or 35 mph maximum speed control
   d. The definition of the area of the earthquake shall be determined by using detectors with several levels of sensitivity. Submit a recommendation for an appropriate method of controlling trains on receipt of an earthquake alarm.

2. High wind (every 10 mi.): High wind shall directly inhibit functioning of the Train Control system with recorded wind velocity greater than 65 mph. Identify the characteristics of the alarms, alarm threshold levels and interfaces with the Train Control system.

3. Encroachment Detector (road vehicles):
   a. Encroachment detectors shall activate when a road vehicle breaks through the parapet of an overpass, parking deck, fencing or other location where a road or facilities allow vehicular traffic to run close to the system and could present a
safety risk. When intrusion is detected, the Train Control system protecting the area affected shall automatically stop train operations.

b. After confirmation by the Train Controller, the first train may proceed manually with caution through the section to examine the site by operations personnel.

c. Restoration of the signaling to normal working shall be achieved by operation of a wayside device in co-operation with the Train Controller.

4. Protection at the MSF Secondary Road Access Road: The primary use of the secondary access roadway is for maintenance personnel and their vehicles to access the yard area and for emergency access by fire department, police, or emergency-medical personnel. To accomplish safe access, there are two gates that shall be controlled and indicate status during the process of gates operations. At the outer gate, there will be a Knox Box installed next to the gate on the outside of the fence. A key inside the Knox Box shall be the means of entry for emergency responder personnel through a motorized sliding gate. The inner gate control panel shall be furnished with an access card reader to open the motorized vehicle swing gates. The entire area between gates shall be monitored by CCTV cameras capable of providing visual detection of any obstruction that could impact train operation. A system shall be provided to detect the presence of vehicles or other trainway obstructions anywhere between the outer and inner gates. The system shall prevent the gates from closing while the detectors sense the presence of a vehicle within the area between the two gates. When the key is used at the outer gate, or an access card is used at the inner gate, the ATS shall schedule the controlled (service brake rate) stop of trains approaching the roadway crossing area. After a time delay of sufficient duration to accommodate the stopping of any approaching trains outside of the roadway crossing, ATP vital systems shall ensure that all approaching trains are stopped and do not block the access roadway area, and confirm the contact rail for adjacent mainline and yard tracks is de-energized. ATP shall only permit the gates to operate (permit access across the mainline and yard tracks) after confirmation that all trains on approach tracks have stopped and contact rail has been de-energized. For the remaining train operation beyond the affected area, the ATS system shall regulate System train movements such that trains shall stop and dwell at station platforms with doors open for the duration of the access gate operation.

5. The Contractor provided gate control panels shall be equipped with light emitting diodes (LEDs) that normally illuminate red symbolizing that the train control and traction electrification systems are energized and operational. A yellow light shall indicate that train control and traction electrification systems in the area are in the process of preparing to allow a safe crossing of all tracks. Once the process is complete, the lights shall illuminate green during the gates operating cycle. When one gate begins its movement, the other gate will simultaneously open. The gate system shall provide a gate open indication to the OCC, train control and traction electrification systems. The gates shall remain open until the detection system indicates the absence of vehicles or other trainway obstructions anywhere between the gates and may then automatically close. = Once the ATP confirms that both gates are closed, service shall be restored by the OCC controller via a command issued from the Yard Control Workstation (TCW) only after visual verification via CCTV that the track area is clear of any obstructions.

6. Normally, the YCW can remotely operate both inner and outer gates. For emergency exiting the MSF, the use of the access card shall perform the identical scenario
detailed above. The control and indications of this Secondary Access scenario shall be displayed on the overview screen and workstations at OCC and YCW.

7. Power for the gate control panels shall be derived from the Uninterruptible Power Supply (UPS) system. There is a provision to allow emergency personnel to use a hand crank, for both locking and unlocking of gates in event power is unavailable for motorized operation. Any unlocking of the gates shall be detected by ATP and shall result in immediate stoppage of all approaching trains and de-energization of contact rail power. Blue Light Stations shall be provided at the exterior and interior gates for back-up communication to OCC and removal of contact rail power.

D. Submit full details of sensors used to detect each type of disaster.

E. The Train Control system shall be capable of receiving and acting on inputs from various disaster systems. The specific action required shall be obtained individually for each system and may involve the automatic imposition of TSRs or the automatic application of service or emergency braking.

F. Audible and visual alarms shall be provided at the OCC, Yard Control Workstation for detectors within the MSF, and at adjacent Station control rooms for high wind, encroachment and earthquake detectors.

G. The effect of activation of disaster systems shall be as stated in the other Sections contained herein.

H. Submit preliminary designs to meet these requirements, which must include comprehensive operating details.

2.04 CONTROL CENTERS GENERAL

A. Common requirements for all equipment to be located at the Operations & Servicing Building are described in the OCC Specification, and these shall be read in conjunction with this Section. In addition, a back-up OCC facility’s (JTMC) requirements are described in Section 27 90 00 – Operations Control Center Ancillary Equipment and Design Criteria Chapter 15 – Communications and Control.

B. This Section details requirements, which shall be met by the OCC and TCCRs.

C. The total area supervised and controlled from the OCC will be displayed in a geographical form.

D. Control and indication requirements shall be based on modern service proven display concept of Video Display Units and/or Mimic Panels. Where all controls are implemented on a VDU, a Mimic Panel may be provided in the form of a display screen, with indications but no controls.

E. Submit clearly the control and indication arrangements for the OCC, both main and back-up, and TCCRs.

F. Not Used.

G. With the physical proximity of the OCC and Yard Control Workstation, these workstations shall be capable of controlling each other’s control areas.

H. Displays General:
1. The lines representing track, controls and indications shall be laid out on a grid and shall be consistent with ergonomic considerations for operation by fifth percentile females to ninety-fifth percentile males of the adult Hawaiian population. The lines of the system shall normally be displayed in a series of horizontal lines.

2. Representation of crossovers, switches, and turnouts shall be unambiguous. No track may be shown to turn at 90 degrees.

3. Submit details of the colors that will be presented on VDUs and/or Mimic Panels.

4. The display shall be capable to be expand for future lines to the system.

I. Workstation VDUs:

1. Lines with no train detection system or non-indicated train detection – gray outline only
2. Unoccupied track circuits or axle counter sections with no route set – solid gray
3. Unoccupied track circuit or axle counter sections with a route set over them – solid white
4. Occupied track circuits and axle counter sections – red
5. Crossover switch in unlocked position- solid gray
6. Crossover switch in locked position – green
7. Crossover switch in motion between positions – flashing red

J. Overhead VDUs:

1. Lines with no train detection system or non-indicated train detection – black outline only.
2. Track circuited or axle-counter-fitted lines – four different colors sequenced in pairs for each normal running direction such that adjacent track circuits are always different colors. Additional colors shall be used where necessary to differentiate between adjacent track circuits or axle counter sections in complex track layouts.
3. Interlockings- Colors same as VDU.
4. Platforms, disaster systems, and other such significant topographical feature shall be clearly identified. In addition, all platforms are to be shown in a color that is distinctive from that used for the background color. Names of stations, turnout’s junctions, and crossovers shall be shown.
5. The signaling indication system shall be distinct from the Traction Power and Electrification system control facility and associated indication equipment, but shall take into account the fact that the two displays will generally be adjacent. Additionally, electric control distribution alarms shall be brought to the attention of the OCC Train Controller through the Train Control system.

K. Controls:

1. General: All control interfaces shall be subject to specific review by the City.
2. Route Control:
   a. The philosophy of the route setting system shall be “entrance – exit” (NX) irrespective of whether a route is set manually or automatically by the ARS.
   b. Setting a route shall involve the activation or operation of an interlocking associated with the entrance of the route followed by one associated with the exit within the same facility.
   c. Such facilities may operate as exits and entrances, but must only do so as a result of separate discrete operations.
   d. Where a route has failed to call within a time period recommended by the Contractor, the entrance shall cancel automatically.
   e. During the setting up of a route, after a device has been operated as an “entrance” it will have associated with it a white flashing indication until an appropriate exit device has been operated when the indication will become steady. All “available” exit devices will illuminate steady white whereupon the selected exit remains steady white while all others extinguish. This will indicate that the route has been called. The indication will remain steady until the route is cancelled.
   f. The cancellation of a route may be initiated by the contrary operation of the facility associated with the entrance used to set it (e.g. pulling the entrance button as opposed to pushing it). On passage of trains, automatic restoration facilities or fleeting shall be used. The entrance indication will only extinguish when these conditions have been fulfilled.
   g. Any device operated as an “entrance” may be cancelled immediately by contrary operation provided that no effective “exit” device has been operated.
   h. Where Call-on Routes are provided, the selection between Call-on Route and associated Main Route shall be carried out automatically upon track circuit or axle counter section occupancy. A single set of entrance/exit devices shall apply to both routes.
   i. Facilities associated with different functions shall be individually distinguishable according to the facility type.
   j. The operation of Main Route setting devices shall result in the establishment of the whole of the route including the Safety Margin (slip limit or overlap). Separate Safety Margin setting devices shall not be provided.
   k. Manual route setting arrangements shall include the facility to select automatic working for main through routes at stations to permit fleeting of trains. This shall be accomplished by the operation of a separate automatic working control. The separate control shall have an associated indication and shall be effective when the main through routes are set. Cancellation of the control shall remove the automatic feature but shall not affect the routes that are set.
   l. For the MSF control, the capability for track blocking shall be provided where route(s) will be prohibited into an individual track.

3. Switch Control:
   a. Switches shall normally be called, set, and locked to either normal or reverse by operation of routes that require them.
   b. There shall be separate arrangements to permit the Train Controller to individually set and lock each switch to either position. There shall be no
confusion of operation between the calling of switches by the individual facility and by calls being applied by routes.

c. Once set and locked by one method, switches shall not be available to be called to the opposite position by other methods. However, routes shall be permitted to be aligned with the position of the locked switch.

L. Indications:

1. General:
   a. Submit details of how all indications will be presented.
   b. There are two levels at which indications shall be presented to the Train Controller:
      1) Overview: The overview will allow summary detail to be available at all times. The overview shall be provided by VDUs and (at the OCC) also on a Mimic Panel.
      2) Detail displays. These shall be provided on VDUs, and show all details.

2. Indications of Wayside Signals:
   a. All indications shall be steady (i.e. not flashing) unless otherwise stated.
   b. Signal indications shall, as a minimum, include stop and proceed indications.
   c. The stop indication of each signal shall normally be red. This indication shall flash when the signal has been cancelled while it is Approach Locked.
   d. The proceed indication, where more specific information is not available, shall be green.
   e. The individual number of each signal shall be displayed, or in the case of VDUs be capable of being displayed.

3. Indications of Driverless ATC Area Status: Submit full details of the indications, which shall show the status of train control conditions along the route. The system shall clearly indicate to the Train Controller the following features:
   a. Proceed/stop indication
   b. Stopping Point with identification

4. Route Indications:
   a. Route setting devices shall operate together with associated indications so as to ensure that the status of the route setting system during the following operations is clearly distinguishable to the Train Controller:
      1) Route setting
      2) Route release
      3) Route cancellation
   b. Manual route setting devices shall be clearly identified as to their purpose as follows:
      1) Entrance only
      2) Exit only
      3) Combined entrance and exits, such as through routing
   c. Identification shall also make clear in which direction each facility is available.
d. Successful operation of an entrance request shall be indicated by flashing white indications of the entrance and exit prior to a route being established. After an effective exit has been established, the indication shall become steady. Route release or cancellation shall extinguish either indication.

e. Line of route indications shall show the direction and full extent of routes set and locked. Switch indications shall be incorporated into route indications such that loss of switch detection shall be immediately obvious to the Train Controller with a flashing red indication.

f. Line of route indications shall be integrated with train movement (track circuit and axle counter section) indications, and shall clearly show sectional release of Route Locking during the train’s movement.

g. Where route indications are displayed by a row of lights, sufficient numbers of lights shall be provided to give the effect of a continuous line of route indication.

5. Switch Indications:

a. The position of switches shall be shown and each switch shall be individually identified. Each switch number shall be displayed, or in the case of VDUs shall be capable of being displayed.

b. Switch detection shall be displayed in line of route and, in the case of Mimic Panels, by indications adjacent to the individual switch-operating device.

c. In the case of Mimic Panels, normal and reverse detection shall be displayed adjacent to the individual switch operating device together with a separate steady white indication, which shall be displayed when the switches are free to move. This latter indication shall flash red when the switches are out of correspondence.

d. In all cases of switches out of correspondence, failure of switch detection to make, or breakdown of switch detection, shall be clearly indicated to the Train Controller both in line of route and at the individual switch-operating device.

6. Track Section Occupancy Indications:

a. A track section can be a track circuit or an axle counter section. When a track section is occupied, red indications shall be selected in accordance with the line of route and shall be displayed identically to the route indications that they replace.

b. Wherever a track section is occupied without a route being set through it, all indications associated with that track section shall be illuminated red. The indications shall be such as to give a pictorial image of the extent of the occupied track circuit.

c. The individual identity of each track circuit or axle counter section shall be displayed or in the case of VDUs shall be capable of being displayed. Track circuits and axle counter sections shall also be specially identified by having separate numbering sequences or other unique identifiers that are displayed when the section numbers are displayed.

d. If the axle counter equipment is able to indicate a failure or reset condition that can be distinguished from the ‘occupied’ condition, submit a means of displaying this condition on the track section on the VDU by a different color or other indication. Submit how the failure or reset condition will be indicated.
e. Where indicated on a hardwired panel each track circuit, shall have a minimum of two lamps illuminated under all conditions.

f. Where track section indications are displayed by a row of lights, sufficient numbers of lights shall be provided to give the effect of a continuous indication.

g. All track sections within a control center’s area of control shall be indicated individually. Track section indications shall be provided on track sections of the transfer track of the MSF interface to give sufficient warning to enable OCC controllers to take necessary actions in respect of approaching trains.

7. Directional Indications: Directional indications shall be provided on Bi-Directionally Signaled lines. The indication shall be an illuminated white arrow showing the direction of movement and placed adjacent to the line concerned.

8. Track Safety Protection Zone (TSP) Indications: Submit its preliminary design in respect of provision of indications to be given in the OCC to show the application of TSPs where such TSPs may have been initiated either locally or from the OCC. In general, such zones shall be denoted by a unique highlight around the track section(s) concerned.

9. Temporary Speed Restriction (TSR) Indications: Submit its preliminary design in respect of provision of indications to be given in the OCC to show the application of TSRs where such TSRs may have been initiated either locally or from the OCC.

10. De-energized Contact Rail System Isolation Indications: Submit details of its preliminary design in respect of indications to be given in control centers to show the application of Contact Rail system isolations. In general, isolations shall be denoted by a unique highlight around the section of track concerned.

11. Alarms and Miscellaneous Indications:
   a. Normally, alarm conditions shall have a visual indication and an associated audible device, which will sound while the controller’s attention is being drawn to that alarm. Acknowledgment of an alarm shall silence the audible device.
   b. Where possible, audible devices shall be common provided that the severity of alarms is grouped according to their importance. A more severe alarm shall be provided for the “urgent” alarms.
   c. A different non strident common audible indication (e.g. a beep) shall be used where it is considered necessary to draw a Train Controller’s attention to a normal operating function and other “non-urgent” alarms.
   d. A logical hierarchical structure shall be applicable to alarms presented at control centers with priority queuing to ensure that a clear unambiguous picture is always presented to controllers in the presence of multiple alarms or emergencies.
   e. Submit its preliminary design in this respect.

12. Train Movement Inhibit System Alarms:
   a. When the train movement inhibit blue signal system has been activated, a steady indication shall be given at the relevant location on the appropriate Train Controller’s workstation. Simultaneously a non-urgent alarm shall be given.
   b. If the train movement inhibit system is still active when the Train Controller or ARS sets the route, an urgent alarm shall be given.
c. When the train movement inhibit system is deactivated, the relevant indication on the Train Controller’s workstation shall extinguish and a non-urgent alarm shall be given.

M. Visual Acuity and Lighting:

1. Indications and lighting shall be such that an individual may read the lettering without resort to other than prescribed correction of vision.

2. Particular attention shall be paid to the lighting arrangements and their interaction with VDU systems so that users do not experience eyestrain and that the picture is not interfered with by reflections.

3. On VDU systems where a background color other than black is used, make clear the reason for the choice.

4. VDU screens shall be constructed using long persistence phosphors.

N. Nomenclature of Lines:

1. Each line over, or from, which a signaled route can be set, shall be clearly named. The name will be displayed preferably above the line to which it refers, and where applicable with one or more arrows indicating the normal direction of movement.

2. The system designation will be provided in the RFP Plans.

O. TT System:

1. General:
   a. The TT system shall have two key functions:
      1) Providing information about the location, direction of travel and status of trains, to staff to enable efficient oversight for the operation and management of the transit system
      2) Providing information to other systems automatically and on demand of the location and status of all trains in the system
   b. Each train consist shall have a train number which will be alphanumeric characters, number of trains in the consist and direction of travel indication, together with a timekeeping character.
   c. Whether color coded or using the last character, the TT system shall show the Train Controller, for each train, whether it is:
      1) One or more minutes early by displaying “+” or unique color
      2) Less than one minute early or late by displaying a blank
      3) One or more minutes late by displaying “-” or unique color
   d. In addition, the TT system shall show for each train whether it is being routed by the ARS or whether manual routes require to be set in order to route it to its destination. The train destination shall be part of the train number along with the train consist.
   e. Train descriptions shall follow train movements without action being taken by the Train Controller. Control of TT stepping functions by the Train Control system shall be such that maximum use may be made of TT facilities during the following conditions:
1) Train Control system degradation
2) Emergency working
3) Permissive working
4) Passing of Stopping Points at stop
f. Submit its preliminary design detailing this feature.

2. The TT system shall provide to other systems either within the scope of the Train Control system or external to it (both included and not included in this Contract), information regarding:
   a. Train position
   b. Train description (number)
   c. Deviation from planned time
   d. Train Destination
   e. Train Consist (number of cars)

3. Such other systems shall include, but not be limited to, the following:
   a. Passenger information system
   b. Automatic public address, both audible and visual
   c. Management information
   d. Staff information
   e. Automatic ticketing
   f. Train running timekeeping and service provision analysis

4. Train Tracker information for use of other systems shall be provided at an interface. In principle, the information shall be made available as follows:
   a. On train movement (Train Tracker step)
   b. On entering or canceling a train number
   c. On setting or canceling an associated route
   d. On entry or exit of the control area
   e. On detection of system failures
   f. On raising of operational alarms or warnings
   g. On demand of other systems
   h. Submit its preliminary design in this respect.

5. Submit detailed information of all the interfaces proposed including, but not limited to, the following:
   a. Electrical standard used
   b. Data transmission rates
   c. Data update rates
   d. Control signals and characters used
   e. Clock requirements
   f. Message and character formats
   g. Protocols used and supported
   h. Data entry and output processes
   i. Message buffer provision
j. System security
k. System test facilities

6. The TT system shall also provide the following facilities:
   a. Clock displays on Mimic Panels, VDUs, and projection systems.
   b. Use of standard reference time (note that the clock is driven by the master clock described in the Communication Systems Functional and Technical Requirements).
   c. Ability to Interpose and cancel train descriptions by the Train Controller.
   d. Provision of a message switching system between TT system users. Such a system shall be capable of insertion/editing of a minimum of three lines of text.

7. Train Tracker Display System:
   a. Submit details of how the TT system displays will be accomplished. It is envisaged that they will be either an integral part of a VDU and/or windows in a Mimic Panel. Displays shall be immediately in rear of (i.e. on the approach to) the signal or incorporated into the section to which they refer.
   b. The provision of a display train description for each signaled Block Section throughout the control area shall be provided for VDU and projection display systems.
   c. As a minimum, the capacity of the display system for Mimic Panels shall be sufficient to ensure that all scheduled trains in the control area at peak service time for the saturated service shall be displayed in their relative positions. Trains additional to this shall be indicated via overflow indicators.
   d. All signal sections in interlocking areas shall be provided with display train descriptions. This shall apply to both Driverless ATC and some wayside signal sections of the MSF.
   e. Where the summary information does not permit the exact position of all trains to be identified, the order of a series of trains proceeding through a section shall be immediately obvious to the Train Controller.

8. Train Tracker to MSF Transmission:
   a. Facilities shall be included for the automatic transfer of train descriptions between the Train Tracker and the Yard Control Workstation.
   b. Normally a train description will be interposed by the Yard Train Workstation when the train or consist leaves the MSF. Thereafter the train description shall automatically transfer to the ATS area and shall automatically step throughout the ATS area during subsequent movements.
   c. Train descriptions shall be transmitted between OCC System Status Display and the Yard Control Workstation in sufficient time for the receiving Train Controller to be fully aware of approaching trains. Such warning shall be given sufficiently early to enable the receiving Train Controller to manually set and clear routes, should manual route setting be required, without impeding the progress of the train.
   d. Individual reminder Descriptions/displays shall be provided at each control center point of departure. The displays shall be provided on VDU screens and/or on Mimic Panels where provided, and shall be positioned adjacent to the associated line.
e. Transmission check facilities shall be included to ensure correct transfer of train
descriptions.

9. Train Tracker Alarms: Audible and visual operational alarm facilities shall be
provided including, but not limited to, the following:
   a. Description Received Warning: A “Description Received Warning” shall be
given to OCC on transmission of a description from Yard. The audible alarm
shall be a non-urgent 1 second tone.
   b. Not Described Alarm: A “Not Described Alarm” (NDA) shall be given when
the conditions for a step from one Description to another occur at a time when
there is no train description present. A distinctive indication shall be inserted
into the relevant Description. The audible alarm shall be an urgent tone lasting
for five seconds, or until acknowledged.
   c. Cancel Alarm: A “Cancel Alarm” shall be raised when the train description
received of an approaching train previously transmitted to and displayed at a
control center is subsequently cancelled by the adjacent (departing) Yard
Control. The audible alarm shall be as for NDA above.
   d. Update Alarm: An “Update Alarm” shall be raised when a train description
received and displayed at a control center is modified by an adjacent Yard
Control. The audible alarm shall be as for NDA above.

10. Train Tracker Repeater Displays:
   a. Simplified repeat TT displays are required to be provided at each station, and at
the MSF, to inform staff of the location of each train on the network. Assume
that a total of six displays are to be provided, i.e. one display for MSF.
   b. A simple overview display showing the whole network and the location of trains
with respect to stations is required. It is not necessary to show detailed track
layouts.
   c. The displays shall indicate whether trains are running early or late, as specified
for ATS displays.
   d. It is preferred that the information is presented as a single view on a VDU or
LCD.

P. VDU Equipment:
   1. There shall be sufficient VDUs so that the Train Controller is able to see the whole
area of his control simultaneously. This may be achieved by having overview
displays with summary detail on them and detailed displays capable of showing full
details as necessary.
   2. Submit its preliminary design for overview displays demonstrating how the following
will be realized:
      a. The overview shall enable the Train Controller to identify all trains within the
area of control
      b. The overview shall be available at all times, and it shall not be necessary to
remove overviews to display detail displays
      c. In station areas, and crossovers, full track circuit, axle counter section, and
switch positions shall be shown
      d. All controlled routes shall be indicated fully allowing the Train Controller to
monitor and set routes.
3. Suitable displays shall be provided to facilitate the operation of all control functions. It shall be possible to display names or numbers of all trackside items (e.g., track circuits, switches, signals) at the behest of the Train Controller. The Train Controller shall be able to switch on or off the various functions (e.g., signals, track circuits, points) individually.

4. Sufficient detailed displays and overview displays shall be available to cover the whole area of control.

5. The arrangements shall be versatile such that it shall be possible for Train Controllers to call up displays on any VDU screen.

6. If necessary, a general display may be provided so that ancillary functions may be separated from the main signaling displays. A general display will typically be used for alarms, TT system, ARS, and system functions. The keyboard may be used to key in routes in addition to operating the other facilities.

7. Controls may be affected by any or all of the following:
   a. Keyboard
   b. Trackerball and push buttons
   c. Mouse and icons
   d. Touch screen

8. The Train Controller shall have at least two independent facilities for the manual operation of signaling functions, one of which shall NOT be a keyboard.

9. Control apparatus shall be durable and robust. Be able to demonstrate a proven service record for the proposed control devices.

10. The user of VDUs shall be able to adjust the brightness, contrast, and color saturation to suit. The user shall be capable of making the required adjustment without leaving his normal position.

Q. Mimic Panel Equipment:

1. General:
   a. A Mimic Panel is a system of display that may be formed by an array of display devices, such as LCD screens, projection devices, VDU screens or faceplates. Faceplate layout, construction, and methods of providing indications shall be subject to specific review by the City.
   b. Faceplate tiles or sections shall be removable to minimize disruption to transit operation in respect of subsequent alteration. Include the minimum size of removable faceplate section that construction methods will permit and shall submit the size proposed.
   c. In order to facilitate faceplate cleaning, flat-top indications mounted to provide minimum faceplate protrusion are preferred.
   d. Colors used for indications shall be durable such that clear distinction is maintained between different colors for the lifetime of the system.
   e. Submit a description of the arrangement made to ensure secure maintainable and alterable mechanical arrangements.
f. Faceplate wiring shall be independent of faceplates themselves to allow them to be removed, and when attached to faceplate mounted components shall be designed so that there is sufficient length to enable the faceplates to be removed.

g. Submit a statement detailing:
   1) The facilities to enable test equipment to be used
   2) The facilities for maintenance lighting (inside the panel)

h. All indications on faceplates shall be LEDs. Submit the type of LED proposed.
i. It shall not be necessary to include forced cooling for either reliability or comfort purposes.

2. Mimic Panels for a Local Control Function at Equipment Rooms:
   a. The requirements of this Section apply only if the Contractor proposes to supply Mimic Panels for local control. In addition, these requirements shall not apply to panels provided for indication purposes only (i.e. display screens or projection screens), where the indications are also available on a VDU.
   b. Steel faceplate construction is preferred to allow the attachment of magnetic reminder devices. Submit the material proposed.
   c. Supply Contact Rail system isolation and TSP zone overlays for application to all control and indication panels as necessary. Overlays shall not inhibit normal operation of controls or visibility of indications.

R. Operational Room Layouts:
   1. Conform to the requirements in Section 27 90 00 –Operations Control Center Ancillary Equipment.

2.05 OPERATIONS CONTROL CENTER

A. General:
   1. The OCC that is housed within the Operations & Servicing Building at the MSF contains the ATS operability, which controls all train movements on the mainline, and access to and from the MSF. The OCC also controls the warning and protection systems.

   2. Ensure that adequate provision is made in the design, layout, and ATC system architecture of the OCC to accommodate other facilities as required. These shall include, but are not limited to, the following:
      a. The Traction Power and Electrification system control facility
      b. Warning and protection systems
      c. Communication systems

   3. The OCC control and indication facilities shall be consistent with and shall accommodate the train control staffing arrangements together with staffing provision specified for the Electrification control facility.

B. System Architecture: The system shall be designed so that in normal circumstances the entire mainline may be controlled by one Train Controller. In periods of high demand, during equipment or systems failures, or during other emergencies that may arise, the system shall permit the workload to be easily shared between two or three Train Controllers.
C. Automatic Line Algorithm:

1. General:
   a. An Automatic Line Algorithm shall be provided to facilitate the system’s traffic management. The system shall involve the automatic production of train graphs detailing actual performance against timetables and shall also have the capability of extrapolation of train paths to facilitate operational recovery from delays.
   b. The Automatic Line Algorithm shall derive its information from the TLMS.
   c. Outputs shall be in the form of distance/time graphs and shall be available on VDUs and as hard copies.
   d. The period displayed may vary from being totally historic to being a combination of historic and forecast, and the Train Controller shall be able to zoom in on a display for more detail.
   e. Predicted and delayed train paths shall be highlighted on all outputs such that these are immediately obvious to controllers.
   f. Submit typical displays and typical printouts and shall include:
      1) Available time frames
      2) Labeling of actual train paths
      3) Labeling of projected train paths
      4) A grid for reference purposes
   g. The Automatic Line Algorithm shall permit the system to be interrogated by the Train Controller to:
      1) Manipulate the time period displayed and the time frame displayed
      2) Input regulation decisions so that the Automatic Line Algorithm can demonstrate the effect allowing the Train Controller to choose the preferred option
      3) Derive train running information on a train-by-train basis in a tabular format
   h. The Automatic Line Algorithm shall include automatic terminal algorithms for each terminal and turnbacks by regulating for the optimal period for turning of trains using all the control of crossovers and platforms necessary for a smooth, timely and efficient turning of consists to continue in revenue service.
   i. The activities: controls, indications and regulation scenarios, associated with the Automatic Line Algorithm shall be logged and shall be capable of logging sufficient data to allow a daily changeover of recording media. This logger shall log all messages received and sent out in a manner that may be easily read by computer.

2. Non-revenue Work Period:
   a. A non-revenue work period is a time in the System made available for maintenance by having no booked services over a piece of track. This may be achieved by routing services over an adjacent track by making use of the Bidirectional Signaling.
   b. Non-revenue work periods are to be clearly identified on the Automatic Line Algorithm screen, and printout where provided, as a block whose length
3. Resolution: Ensure that the screen size and picture definition on the VDUs displaying Automatic Line Algorithm details shall provide for a clear resolution of the image.

4. Speed Restrictions: To enable the Automatic Line Algorithm to make allowance for speed restrictions in its predictions of future running there shall be a system whereby TSRs may be entered directly or derived from information provided for the ARS.

5. Optimized System Performance – Automatic Line Algorithm allows automatic reduction in performance during off-peak service to reduce energy consumption. The vehicle based automatic on-board energy storage mode allows trains to automatically commanded to de-energize power consuming train subsystems, reducing energy demand and equipment life cycle costs.

6. Traction Power Optimization - Automatic Line Algorithm shall optimize the usage of power particularly since the vehicles are equipped with regenerative braking systems. Automatic Line Algorithm shall optimized the schedule to match acceleration and braking of different vehicles in order to reduce the power demand per traction power segment area.

7. Advanced Power Optimization - With additional information on passenger loading, Automatic Line Algorithm shall optimize the velocity profiles and power utilization of the trains to be more accurately modeled and the power optimization to be more finely tuned.

D. Diverse Routing: Ensure that full physical diversity shall be provided between the ATS system at the OCC and either remote interlockings or wayside equipment as appropriate.

E. ARS:

1. General:
   a. An ARS system shall be provided to set routes automatically throughout the mainline, Ready and Layover Tracks and for access to and from MSFs. The ARS system shall provide the following facilities:
      1) Be capable of operating booked services to its planned path from the point of inception to the point of termination.
      2) Be capable of automatically changing a train description where a train has completed one booked path and is about to embark on another booked path. This facility is known as Automatic Code Insertion. This shall be accompanied by an alarm as described in this Section.
      3) Be able to regulate routing clashes and minimize the overall delays that arise from late or early running of scheduled services.
      4) Be capable of checking and monitoring the correct sequence of operation of track circuits and axle counters.
      5) Be tolerant of partial unavailability of signaling facilities.
   b. The ARS shall be sub-divided into districts that shall generally relate to station or interlocking areas or parts of such areas. It shall be possible to either enable or disable ARS for a particular district. As the system expands, these districts shall be the sections of construction. However, the final system shall be subdivided for the entire 20 mile system.
c. Submit preliminary design for the sub-division of the whole of the mainline into ARS districts.
d. The train service data for the ARS will be derived from the TLMS.
e. The ARS shall be installed to perform route setting and train regulation for the whole area under control of the Train Controller at the OCC recognizing the additional constraints of the future at-grade turnouts for added lines to the 34-mile system.
f. Route setting shall match the planned timetable when all trains are running as scheduled. When train services are disrupted, ARS shall make decisions to regulate the service to achieve minimum delay to trains. It is preferred that means shall be provided to enable such ARS decisions to be automatically referred to the Train Controller acknowledgement prior to implementation. The Contractor’s preliminary design for this facility shall be fully detailed.
g. When it is not within the capability of ARS to keep trains moving to achieve an optimum solution, it shall keep them in line with the general plan of the timetable or some other contingency plan that may have been installed.
h. The ARS shall act based on what is happening rather than what ought to be happening: trains will only have routes set for them once they have been recognized by the ARS and are included in the timetable data.
i. When ARS is operational, manual route settings will not be inhibited and will not require special enabling actions. Manual route setting shall always take priority over automatic operation.
j. The Train Controller shall be able to switch off the ARS per interlocking or line section between stations at any time.
k. The ARS shall warn the Train Controller of conditions affecting its normal operation.

2. ARS Signaling Interface:
a. ARS districts shall be able to be switched ‘on’ or ‘off’ separately by the Train Controller and an indication of the status of each district shall be given to the Train Controller.
b. Manual route setting, and cancellation, shall be available in parallel with ARS and shall cause no additional activity to the Train Controller as a result of the ARS being present.
c. Routes set by the ARS shall be displayed in an identical manner to those set manually.
d. The ARS shall establish the availability of a route before calling it.
e. Should communication to one or more interlockings or wayside equipment be unavailable, ARS shall continue to operate in all areas not affected by failure.

3. ARS Train Controller Interface:
a. The Train Controller shall be able to:
   1) Operate the ARS and receive information from it.
   2) Selectively control individual trains by automatic or manual means and be able to determine by which method each train is operated.
   3) Adjust ARS operation to compensate for unavailability of signaling functions. This compensation shall automatically force trains to bypass
affected areas. Ordinary planned train services and those whose path has been compensated for the above reasons shall be easily distinguished.

4) Determine where the ARS will next route a train.

5) Pre-select the application of manual operation of signaling functions as compensation for circumstances that require methods of operation beyond the scope of the ARS. Such pre-selection shall be visually indicated and provided in a fail-safe manner.

6) Ascertain the booked timetable of each train under ARS control.

7) Engage and disengage ARS districts.

b. The display of ARS and non-ARS trains on Train Controllers’ VDUs shall be clearly distinguishable.

c. Logging and print out facilities shall be included to record Train Controller intervention in the ARS system and modifications to the time schedule.

4. ARS Train Tracker System Interface:

a. The TT system shall provide the identity and position of each train. Changes of state shall be sent automatically and a full update shall be available on demand.

b. The ARS shall be capable of interposing, canceling and updating descriptions in accordance with the TLMS data. Such action shall be accompanied by a short non-urgent alarm tone.

c. The ARS shall be tolerant to incorrect sequences of messages emanating from the TT system and shall be able to recover from such incorrect sequences without controller intervention.

5. ARS TLMS Interface:

a. A TLMS shall be provided to work in association with the ARS. The ARS will require the TLMS to have the following data for it to be able to function correctly:

1) Current timetable
2) Standard timetable (point to point timings)
3) Contingency timetables

b. Each timetable entry shall include:
1) Train description (train number)
2) Priority of service
3) Timing points including separate arrival and departure times
4) Designated platforms and tracks where defined

c. ARS shall be capable of requesting and storing the whole timetable for at least the current 24-hour period.

d. Lack of data from the TLMS shall be notified to the Train Controller.

e. The TLMS shall be such that data may be generated and edited by non-specialist staff. State in the submission how:

1) TLMS data will be generated and edited and what facilities will be available to timetable planners, Train Staff and maintenance managers and Train Controllers to ease this process.
2) As the timetable planners’ facilities are to be off-line, data will be transferred to the on-line system. Submit full details of interface and message transfers as called for in these Signaling Requirements.

6. ARS Performance – General:
   a. The ARS shall be capable of operating such that there shall be no apparent delay to the Train Controller.
   b. Submit a statement of the worst case degradation of performance together with the circumstances that will result in such degradation, the method of calculation, and all assumptions made.
   c. ARS Route Setting Performance:
      1) Submit the maximum number of routes that may be set in any one minute and shall demonstrate that this meets the needs of the timetable. This figure shall apply to the setting of routes located anywhere on the ARS area.
      2) The ARS system shall at all times route correctly route trains to their correct destinations.
      3) Submit a summary of all actions that the Train Controller must normally take to operate all the trains within the area of control where services are running to schedule. The summary shall assume that ARS is in full operation.
   d. ARS Regulation Performance:
      1) The ARS shall regulate at least as well as, but preferably better than, the standard of a competent Train Controller.
      2) The ARS shall resolve all day-to-day regulation conflicts between trains whose route setting is under ARS control.
      3) Regulation shall include:
         a) Conflicts at points of convergence at at-grade turnouts and terminals
         b) Conflicts between following trains including the recessing of those with lower priority to allow those of higher priority to pass
         c) Conflicts over single line sections between opposing trains including sections of single line working brought in, in association with maintenance work
         d) Conflicts at points where de-energized third rail contact rail exists and route trains accordingly to avoid these sections
         e) Speed and acceleration performance adjustment of individual trains by controlling spacing using commands to each train in the system
         f) Adjustments of individual or multiple trains by the use of platform dwell control of holding train with doors open or closed
      4) Calculations shall take into account all trains affected by a predictable regulation decision.
      5) The ARS shall regulate the terminals, turnbacks and at-grade turnouts to minimize delays by regulating the potentially affected train’s speeds and acceleration mode. The Train Control system for the associated interlocking(s) shall use methods to optimize the regulation of train movements.
   e. ARS Operations: Regulation of trains shall be based on the following principles:
1) When all trains are running on schedule, they will be sequenced as defined in the timetable.

2) When running off schedule, ARS shall minimize delay to all trains affected. For example, where two trains are approaching a point of conflict in one direction, the delay experienced by regulating the second train shall be included in the delay calculation.

3) Each train’s delay shall be weighted to one of four weights assigned in the TLMS.

4) Timetable order shall be maintained where the weighted delays incurred in doing so are small.

5) The ARS shall regulate according to actual events and the timetable requirements.

6) Submit a description of how the system will operate. The description shall take into account, but not be limited to, the following:
   a) Departure time
   b) Train ‘weight’ factor
   c) Platform allocation
   d) Add/Delete trains from service
   e) Skip Stopping of trains
   f) Dwell and door operation control
   g) Turnback services
   h) Level turnouts (at-grade)
   i) Automatic Code Insertion to the TT system when a reporting number is booked to change
   j) Bi-directional operation
   k) The introduction and utilization of pre-planned contingency plans

ARS Route Setting Requirements:

1) The ARS system shall set routes ahead of train movements. Such route setting shall achieve the following criteria:
   a) Routes shall be set far enough ahead of train movements to ensure that speed restrictions unnecessarily
   b) Routes shall not be set so far ahead that optimum train regulation is compromised

2) Trains shall not be delayed unnecessarily by the ARS.

3) ARS shall permit trains to run with the least possible restriction.

4) Routes shall be set by ARS only when all of the following are satisfied:
   a) The train is present and at a point where a route requires to be set
   b) The train has an entry in the TLMS or is running to a standard pattern
   c) The train is progressing along a scheduled route or a permitted alternative route
   d) The next route required is designated as requiring setting by the ARS strategies
   e) The train is a designated ARS train

5) ARS may set a route only when the route:
a) Is available to be set with all signaling control requisites needed and
b) Is an ARS route.

6) ARS may only work where routes are restored automatically by the
   passage of trains. This capability is defined as fleeting.

7) Manual cancellation of a controlled or automatic route shall cause the
   associated ARS to revert to manual control. ARS working may only then
   be reestablished by the Train Controller.

8) Submit its preliminary design in this respect.

g. ARS Operation Under Failure Conditions: The circumstances in which the ARS
   shall continue to operate are:
   1) Loss of a single TT system step
   2) Duplication of a step message
   3) In the presence of a corrupt train description
   4) A signaling function failure
   5) A train failure
   6) The presence of a non-ARS train
   7) Signaling function disconnection

h. ARS Alarms Required: ARS alarms shall be generated for the Train Controller
   in each of the following circumstances:
   1) Changes of state of the ARS, or of zones within it that is becoming either
      available or unavailable.
   2) Changes of state of information from the TLMS.
   3) The inability to correlate train descriptions in the TLMS with those of
      trains in the TT system.
   4) Trains being run to a path not prescribed to them in the TLMS.
   5) The inability to set a route for any particular train for the following
      reasons, as an example;
      a) A de-energized section of third rail
      b) Switch Machine out-of-correspondence
      c) Encroachment detection
      d) Temporary speed restrictions
      e) Seismic and High Wind detection
   6) Trains that have had a route set for them and fail to move within 3 minutes.
      This time shall be adjustable by the City.
   7) When the sequence of operation of track circuits is incorrect.
   8) Automatic Code Insertion operation.

7. Incident Management:
   a. Management of major incidents and emergencies including the co-ordination of
      transit and emergency services will be carried out from the OCC.
   b. Where Mimic Panel overviews are provided they shall be available to be used
      by the incident management team.
   c. Where all VDU systems are provided, an Emergency Services Controller
      Workstation shall be provided for supervisory and incident management
      purposes. The Emergency Services Controller Workstation shall be capable of

displaying overviews for the whole route simultaneously. Control facilities shall not be available from the workstation.

8. OCC Training Workstation:
   a. Provide training workstation(s), at the Operations & Servicing Building, in order that controllers (OCC, Yard, and TCCR) may be trained.
   b. The OCC training workstation shall provide facilities for the training of the OCC staff in the operation of Signaling, Communications and Electrification.

2.06 YARD CONTROL & SIGNALING

A. Control Area: Yard Control Workstation shall control the Manual area of the MSF.

B. Staffing: Control and indication arrangements shall be provided such that the mode of operation shall be possible by a single Yard Train Controller. Controls shall be such that they can be operated by the seated Train Controller in the OCC. Account shall also be taken of staffing provision associated with specified arrangements for the Electrification system control facility.

C. Line Speed: The permitted Line Speed shall not exceed 10 mph throughout the Manual area of control.

D. Not Used.

E. General Signaling Arrangements:

1. Provide signaling arrangements, which are consistent with the proposed method of working of the MSF, and shall submit full details including how the proposals cater for the following:
   a. Safe methods of working
   b. High availability of facilities
   c. Flexible working arrangements
   d. Staff safety requirements

2. Not Used.

3. Submit a description of the signaling arrangements controlling movements between and controlled by the Mainline OCC and Yard Control.

4. Movements between the MSF and the mainline and vice versa shall be controlled by the Driverless ATC system. Each lead will split into two tracks once in the yard that route to/from the ready/layover tracks controlled by OCC. Staging space will be provided on the ready/layover tracks to hold up to two four-car trains on each of the two tracks that be treated as exclusive from yard personnel. A third ready/layover track is planned for future expansion.

5. A transfer zone shall be used for the hand off area between the Manual area of the MSF and the driverless Automatic area of the MSF and mainline system. Two 250-foot sections of track form transfer areas that are coordinated for both the mainline automated and MSF non-automated operations.

F. General Operating Arrangements:
1. The transition of control between OCC and Yard Control will take place at the
designated transfer zones in the yard that are located adjacent to the two
ready/layover track leads as described in Technical Provision TP-03, “O&M
Performance Requirements,” and Design Criteria Section 14.7.1. OCC will govern
all fully-automated movements in the Automated sections of the yard, including
layover/ready tracks and the yard leads. The OCC Yard Control Workstation will
govern all manually-operated train movements in the yard, but never where such
movements are located within fully-automated territory. At these transfer zones, the
OCC Yard Control Workstation will assume responsibility for the train once it is
placed in manual by the action of an authorized yard operator. OCC will resume
responsibility for the train once it is restored to automatic operation once the OCC
Yard Controller assures the train operator has completed all prescribed pre-revenue
testing, confirms the vehicle is operational for revenue service and the operator is
clear of the vehicle prior to its automated movement.

2. The safety of the operators shall be of paramount importance and detailed in a
preliminary report.


4. All crossovers to be located in manual territory in the yard will be power operated
and controlled by Yard Control. Routing movements within the MSF shall be
controlled by wayside signals or indicators. Line-of-sight rules will be in effect in
manual territory within the yard.

5. Because of the unusual nature of these transfer zones, propose additional protection
measures to be applied to control train movements, such as a train stop system, and
shall submit its preliminary design with full justification for their use.

2.07 TRAIN CONTROL/COMMUNICATIONS ROOMS (TCCR)

A. The TCCR at each station shall provide facilities for local operation of the interlocking
and adjacent interlockings. These facilities are required for use in the event of failure of
the data transmission system or non-availability of the OCC for any reason.

B. The Train Control system shall incorporate a secure changeover arrangement between
local and OCC control of an interlocking area including status indications at both the OCC
and the TCCR clearly indicating which facility is in control. As the facility must provide
for local control in time of link failure, the TCCR shall be the master site, in deciding
which site controls an interlocking.

C. In all circumstances where there is a loss of communication link between the interlocking
and the OCC then the TCCR shall not be able to seize control of an interlocking without
being granted a release by the OCC.

D. Where a TCCR has not seized control of the interlocking, then the indication system
associated with it shall be available to the local technician for maintenance purposes.

E. The emergency local control arrangements provided at the TCCR shall include provision
for:

1. Controls

2. Indications
3. General alarms
4. Disaster system alarms
5. TSP and TSR facilities
6. Telecommunication facilities
7. Train trackers (including station-to-station transmission)

F. The following facilities are not required to be provided at the TCCR:

1. Automatic Line Algorithm
2. ARS

G. Submit detailed design for the temporary control from TCCRs, prior to completion of, or connection with, the OCC. Consider and submit preliminary design for enhancing the facilities provided at these TCCRs, as they will be in use for a relatively long period.

H. In addition to the UPS equipment specified for TPSS equipment (see TP 8, Section 34 20 45) the Core Systems Contractor shall provide Train Control and Communication (TCC) Uninterruptable Power Supply (UPS) equipment at all passenger stations for essential power loads in accordance with the Design Criteria Section 20.4.4.2. Equipment provided by the Contractor shall meet all applicable requirements for essential loads in accordance with these specifications, including but not limited to the following:

1. UPS systems shall conform to all requirements of Standard Specifications Section 26 33 53.

2. Interfaces shall be coordinated with the station and MSF design and construction teams and others. Refer to Design Criteria Section 20 and MP-1 for additional interface coordination information.

3. Equipment requiring uninterrupted power, in the event that primary power is unavailable, shall be supported by the TCC UPS. The Core System Contractor shall identify those functions requiring UPS backup as part of the Design Review. Uninterruptible and normal backup power shall be provided for at least the following functions:
   a. ATC.
   b. Central Control to/from vehicle communications.
   c. CCTV.
   d. Station public address and emergency telephones.
   e. Power distribution system control power subsystem.
   f. Radio systems.
   g. Core System Contractor provided fire, safety and security equipment.
   h. Station variable Message Signs/preprogrammed announcements, if applicable.
   i. Any data transmission system.
   j. All system alarms.
   k. Station door controllers, alarms, and operating mechanisms.
   l. Intrusion alarms.
The UPS equipment shall be sized to provide power for all of the above functions for at least two (2) hours or longer if determined to be necessary by the Hazard Analysis.

4. UPS status (e.g., on-line, by-pass, etc.) shall be indicated at Central Control. Changes in status, such as load on battery, load on auxiliary source, low battery, shall be alarmed, and logged.

5. UPS batteries shall be of the valve-regulated lead acid type as specified in Design Criteria 20.5 and equipment shall be placed as specified by Design Criteria 20.5.1. Refer to Directive Drawing ED0002 for passenger station single line electrical diagram and ED0008 for UPS equipment layout.

2.08 DRIVERLESS AUTOMATIC TRAIN CONTROL SYSTEM

A. General Requirements:

1. The Driverless ATC system shall be employed throughout the mainline and the ready/layover tracks and also for running movements into and out of MSF.

2. Driverless ATC systems shall be regarded as a vital system.

3. Submit clear details of the whole system with identification of the fail-safe levels and elements incorporated therein.

4. The Driverless ATC system shall provide full and complete wayside to vehicle information to permit interpretation of signaling and permitted speed conditions together with a direct link to the train braking system to automatically enforce train braking in the event of excess speed.

5. The Driverless ATC system shall provide comprehensive speed supervision incorporating, but not limited to, the following:
   a. Utilization of predetermined braking curves that is generated from the vehicle’s characteristics
   b. Monitoring of signaling and other speed limiting conditions
   c. Computation of permitted speed
   d. Continuous monitoring of actual train speed
   e. Continuous comparison of actual speed with permitted speed
   f. Automatic application of braking in the event of excess speed above a margin

6. The system of communication between wayside and train shall ensure that data capacity and exchange rates are sufficient to guarantee the specified Signaling Headway and capacity requirements.

7. Ensure that the ATP system does not automatically invoke an emergency brake application on loss of the Contact Rail system voltage, unless the Contractor demonstrates that not to do so will compromise system safety.

8. In the latter case, provide the City with a report not later than 90 days after the Notice to Proceed.

B. Functional Requirements:

1. Driverless ATC may be based on a fixed block, moving block, or hybrid system.
2. In determining the level of movement authority to be given to a train, the system shall take into account all relevant data including, but not limited to, the following:
   a. Presence detection
   b. Safe train separation
   c. Location of train, limits of consist that includes definition of the front and rear ends
   d. Location of Stopping Points
   e. Right-of-way hazard detections
   f. Rollback protection
   g. Reverse operation interlocks
   h. No motion detection
   i. Overspeed protection
   j. End of Track protection
   k. Signal transmission and detection
   l. Door opening/closing operation
   m. Vehicle/station berthing interlocks
   n. Pre-departure testing
   o. Departure interlocks
   p. Unscheduled door opening protection
   q. Interlocking safety protection
   r. Permanent speed restrictions
   s. Temporary speed restrictions
   t. Track safety protection zones
   u. Absolute block protection
   v. Type of route that has been set
   w. Gradients
   x. Vehicle characteristics, which includes the emergency brake rate
   y. Broken rail detection
   z. Program Stop at stations
   aa. Platform Fall Detection

3. Submit a description on how the driverless automatic train control system fulfils each of the above items.

4. As a fallback, information given via the operator’s interface together with wayside indicators or markers, as required, shall form a comprehensive Train Control system enabling trains to be moved safely and efficiently up to the full capacity of the line.

5. The Driverless ATC system shall be configured for bi-directional automatic control throughout the system.

6. Submit a statement on how the positioning and identification of Stopping Points is to be determined.

7. When traversing temporary speed restrictions (TSRs) the train speed shall be restricted for the length of the TSR only, taking into account the length of the train
consist. Trains shall not be restricted unnecessarily under such conditions. Submit its preliminary design in this respect including limitations or constraints.

8. The Driverless ATC system shall be capable of dealing with all classes of route required including, but not limited to, the following:
   a. Main Routes
   b. Crossover Routes
   c. Call-on Routes

9. Detection of irregular wrong direction movement of a Consist by the Driverless ATC system is required and shall result in an emergency brake application and associated alarm being given to the recovery operator.

10. Under certain operational conditions such as emergencies, train failures, signaling failures etc, it will be necessary for trains to pass Stopping Points under safe working procedures. The Driverless ATC system shall facilitate such operations; submit details of how this will be achieved. Details shall include, but not be limited to, the following:
   a. Means by which the OCC Train Controller or recovery operator may override the Train Control system
   b. Permitted speed under emergency and failure conditions
   c. Distance to next target
   d. Action at next target
   e. Transition back to normal operation

C. Line Capacity and Headway:

1. The Driverless ATC system shall be capable of providing the full line capacity and Headway specified. Particular attention shall be given to signaling arrangements in station areas to ensure efficient operation in respect of:
   a. Overtaking movements
   b. Turnback movements
   c. Terminal operations
   d. Programmed station stops for either normal or reverse directions, stopping the consist automatically at a predetermined point
   e. At-grade turnouts

2. Clearly detail how such requirements are achieved and submit a detailed description to the City.

D. Bi-directional Operations: Clearly detail the method by which the Driverless ATC system shall be configured and shall operate in respect of Bi-directional Operations to attempt to maintain normal operations with failure(s).

E. Uncoupling: Whenever a train separates, one vehicle will be moved away from the stationary vehicle(s) at restricted speed and acceleration. Detail the requirements for presence detection and safe separation to recognize the two newly created trains.

F. Trackborne Maintenance and Testing Vehicles: All rail vehicles used for maintenance, testing, and rescue vehicles shall be fitted with Driverless ATC system equipment and shall be able to make full use of the Driverless ATC system. This equipment shall include
additional protection systems used in conjunction with the fallback Train Control system. Submit specifications, interface and on-board space requirements for such vehicles and shall make available to the vehicle manufacturer all necessary equipment and information to install it. Take into account of the variable train characteristics of the fore mentioned vehicles/locomotives and require proper response of the Driverless ATC system.

G. Operator’s Interface:

1. The operator’s interface, including all data, displays, audible and visual alarms, controls, operator’s actions etc, shall be subject to specific review by the City.

2. The operator will only normally operate the vehicle in the forward direction. Strict precautions shall be provided for reverse direction operation. Provide sketches showing the layout of instrumentation, acknowledgement, precautions and other devices including operator’s input devices.
   a. The operator’s interface shall provide a comprehensive and logical link with the Driverless ATC system. Provide full details of the operation of the operator’s interface is described in the Vehicle specification.

3. Provide full details of instrumentation and audible devices including, but not limited to, the following:
   a. Calibration (including wheel diameters), accuracy, responsiveness of instrumentation
   b. Clarity of indications in the presence of ambient light and reflections
   c. Display brightness adjustment
   d. Clarity of audible warnings in the presence of ambient noise
   e. Discrimination of urgent and non-urgent alarms

4. Provide details of initialization and shutdown procedures for Driverless ATC systems including, but not limited to, the following:
   a. Details of operator’s input devices
   b. Methods of inputting data
   c. Types of input data
   d. Blue Signal Protection
   e. Initial checks and testing protocols
   f. Recovery from Consist or Electrification system failure
   g. The safe boarding and disembarking of the consist by the operators.

H. System Configuration and Hardware:

1. Provide full details as to the overall system configuration broken down into the following systems:
   a. Wayside
   b. Track mounted
   c. TCCR
   d. OCC
   e. On-board vehicles
2. Details of system hardware shall be given for each of the above categories, together with a description of the function of each element.

3. Communications links between wayside and train shall be suitable for the Line Speeds and conditions specified. Such communication shall be effected by on-track devices, or other means, details of which shall be submitted by the Contractor, and shall include full details of message exchange including, but not limited to, the following:
   a. Coding
   b. Security
   c. Capacity
   d. Data rate
   e. Usage by other on-board systems

4. The communications system between trackside and train shall be secure and shall ensure that trains only react to messages that are meant exclusively to on-track devices. Detail precautions taken to achieve such security and vitality to be called “safety critical.”

5. The system shall be immune from train location errors caused by wheel slip and slide. Submit measures taken to effect such protection together with methods of recalibration.

6. Suitable transition arrangements for the MSF transfer tracks shall be provided between Driverless ATC areas of the mainline and wayside signaling area of the yard. Submit details of how this will be achieved.

7. Details of Operations and Maintenance information for all system hardware and software shall be provided and updated as equipment and subsystems are modified or upgraded.

I. System Degradation and Failure:

1. Systems shall be designed and configured such that the effects of system degradation on the operation of trains shall be minimized.

2. State levels of degradation and submit details of methods of train working for each level of degradation. Such details shall include arrangements for the working of trains under total system failure.

3. Detailed preliminary design involving disabling or override of the driverless control and/or braking controls shall be submitted by the Contractor.

4. Operation of all trains under system degraded conditions together with associated safe working procedures and practices shall in total produce a level of safety not less than that applicable to a fully functional Driverless ATC system.

5. Submit details of wayside signals or indicators, and train protection systems, required for operation under degraded conditions.

J. Event Logging: Automatic logging of system operation shall be incorporated for principal events. Submit design, at all levels of development, in this respect including, but not limited to, the logging, analysis, and presentation of results of:
1. Initialization and tests
2. Shutdown
3. Operator’s input data
4. Intervention
5. Emergency braking
6. Disengagement of functions
7. Passing of Stopping Points
8. System operation
9. Signaling status
10. Permitted speed
11. Train speed
12. Train position

2.09 TRACK PROTECTION SYSTEMS

A. General:
   1. This Section describes the signaling warning and protection facilities provided to protect:
      a. Staff and trains in defined areas by enforcing a reduction in the speed of trains
      b. Staff by preventing trains from entering designated areas
      c. Passengers on platforms
   2. Such systems shall be classified as vital systems.
   3. Safety of staff working on or near the track will be covered by the operational procedures for the system: under normal circumstances, staff will not be in the track safety zone when passenger trains are running being an exclusive right-of-way.
   4. Provide flexibility in the preliminary design to accommodate the City’s requirements in the sectioning of Track Safety Protection Zones and Temporary Speed Restrictions.
   5. Submit details of the following train protection systems, required for transit operations.

B. Track Safety Protection Zones:
   1. The principle unit of staff safety will be the Track Safety Protection Zone (TSP): other systems shall only be used when use of a TSP is impracticable. The precise coverage and quantity of each TSP will be confirmed only after the ATC scheme plan by the Contractor has been completed. However, for the purpose of the preliminary design the following basis of TSP definition shall be used:
      a. Each Block Section along the Line
b. Each platform track  
c. Each junction area between the Stopping Point at the platform end and the Stopping Point protecting the junction  
d. Others as deemed necessary as the Contractor’s design progresses

2. Means shall be provided for extending the coverage of TSPs by combination of two or more TSP sections.

3. TSPs shall be imposed at the vital level and shall be initiated by either of the following:
   a. Operation of wayside devices by staff  
b. Where applicable, operation of devices in TCCRs  
c. Where applicable, OCC, if vital

4. TSP devices shall normally be operated only in co-operation with the OCC Train Controller. When operated without the co-operation of the Train Controller, then operating the device shall effectively be an emergency control Replacement.

5. For each TSP, wayside devices shall be provided at both ends of each section.

6. When activated, each TSP zone shall have the effect of introducing a zero speed TSR throughout the designated section, directly preventing the running of trains through the section. Approach speeds shall be provided to regulate the train’s speed for the passenger’s comfort.

7. Switches for TSPs which lie between two platforms and that are mounted on the station for use by operations staff shall activate both TSP zones between the platforms.

8. Unless it is acknowledged by the OCC Train Controller as part of the process of imposition, a call to implement a TSP by any of the initiating devices shall cause the appropriate track circuits or axle counter sections to show occupied and generate an ‘urgent’ alarm.

9. Provided the OCC Train Controller follows the acknowledgement process, specified by the Contractor, no alarm will be raised and an indication shall be given that is obvious to the Train Controller.

10. Additional TSP wayside devices shall also be available for use as emergency protection devices for operation by both transit staff and City/County of Honolulu emergency personnel. In this respect the following shall be provided:
    a. Wayside devices shall be mounted on platforms where appropriate  
b. Wayside devices shall be accessible to transit staff and others

11. Removal of TSPs once imposed shall not be achievable by a single action. Such removal shall only be effective in co-operation with the OCC Train Controller.

12. Where TSP protection covers only a single track, demonstrate the means by which staff using the TSP will not be in danger from train movements on other track(s). The factors to be addressed shall include, but are not limited to, the following:
   a. Aerodynamic protection from other trains, by imposing a TSR on adjacent tracks
b. Means by which staff will be prevented from straying off the protected track

c. Signage to ensure staff is fully aware which lines remain open to traffic

13. Where a TSR is to be imposed on an adjacent track as part of TSP protection, this shall be done automatically when the TSP is imposed, and shall not require a separate action.

C. Temporary Speed Restrictions (TSRs):

1. In addition to preventing trains being signaled through any section of line, it shall be possible to impose TSRs to temporarily restrict the speed of a train through any section. This function shall also be available for providing TSRs for engineering purposes, or for emergency speed restrictions for any purpose.

2. Approach speeds shall be provided to regulate the train’s speed for the passenger’s comfort. Clearance of the entire consist shall be required prior to the restoration vehicle’s speed authorization.

3. The sections in which TSRs can be imposed shall be co-incident with the section used for TSPs.

4. Imposition of TSRs shall be effected at the vital level.

5. The preferred method of imposition is by the OCC Train Controller. However, the Maintenance personnel shall also have the ability to impose TSRs. Submit details of how TSRs are to be imposed and what restrictions and limitations there are on such impositions.

6. Submit a table of speeds that may be imposed.

7. Removal of TSRs once imposed shall not be achievable through a single action, to prevent accidental cancellation.

8. The location of TSRs and the temporary speed limit imposed shall be obvious to the OCC Train Controller. This indication shall be positive confirmation that the TSR is effective at the vital level. Submit a description of how this is achieved.

2.10 ALTERABILITY

A. General:

1. Alterability means the capability to amend the train control arrangement to take account of changes to the transit system’s layout and/or operations sometime in the duration of this Contract or in the future. The layout changes may comprise of line extensions to the transit line, additional tracks (crossovers, turnouts, sidings) and connections to them, or the removal/repositioning of existing tracks. It also includes the ability to amend the permitted speed on any section on the mainline.

2. It does not include the ability to change the fundamental parameters of the Signaling or ATP systems. Examples of these are:
   a. A change from fixed to moving block
   b. Re-location of the OCC or Back-up OCCs
   c. Increase of Line Speed above the speed defined in Technical Provision TP-03, “O&M Performance Requirements”
d. Modification of the Train/Consist braking rate

3. Provide alteration capability to enable the City to make such alterations without recourse to the Contractor. This will include the means to design alterations and to amend and test data pertaining to the interlockings, terminal locations or systems. Also includes the various associated non-vital systems, which comprise the man-machine interfaces and the ATS network. The alteration shall be accomplished without affecting the source software program, only by application data alteration.

B. Hardware: Where a module requires application data to enable it to function, it shall be immediately apparent which data (including version numbers, issues, modification states etc) is contained within the module, without making disconnections.

C. Data:

1. Data may be of two types, system data (that which is necessary to make generalized programs suit their purpose) and application data (that which relates to the specified environment). System data shall be treated in the same manner as software (see Article 2.10D herein), and describe how the data meets these requirements.

2. Application data shall be entirely user configurable. The structure of the data and the system requirements to manipulate such data shall be such that a competent signaling designer will be fully conversant with the techniques and methods necessary.

3. Application programming for electronic interlockings shall only require knowledge of interlocking design and circuits to configure or re-configure an interlocking.

4. Submit separately all materials and information associated with the provision of alterability to be provided to the City. Classify the issues according to the provision of:
   a. Dedicated hardware and software
   b. Training
   c. Documentation

D. Software:

1. Software (and system data) shall be geographically independent, that is the Software configuration of modules must be only related to its function not its location.

2. Submit a description of how the proposed Software meets these requirements.

3. Modules once configured by the system to one location shall require an assured deconfiguration and reconfiguration procedure before they may operate in a different location.

4. Supervisory parameters such as the number of modules in the system, or the relationship with other systems, shall form part of the application data and not be part of the Software or system data.

2.11 AUTOMATIC PLATFORM DOORS

A. General platform door requirements
1. Platform edge barrier walls and vehicle-to-platform coordinated barrier wall door equipment (platform doors) provided under this contract shall be designed and provided in accordance with Section 10.2.1, Intrusion Prevention System, ASCE 21-3-08, and shall be provided for the full length of the platform providing a separation between passengers on the platform and the guideway. Platform doors shall interface with, and be controlled by, the ATC/ATO/ATP system provided by the Core Systems Contractor as specified in this TP-8, Division 34 44 00 and Design Criteria Chapter 14. Refer to MP-1 “Systems Interface Management & Coordination” for interface information. Platform doors shall open automatically and in coordination with train doors and shall allow passengers to board all vehicles of up to a train of maximum length whose doors are properly aligned with the platform doors in accordance with Design Criteria Ch 14, Section 14.2.8 and ASCE 21-05, Section 5.2.2. Platform door equipment provided by the Core Systems Contractor shall include all necessary control and power wiring.

2. Platform door operation, including at least door open commands, dwell, door closed commands, and door recycling, shall be controlled by the ATO subsystem as described in Design Criteria Ch 14, Section 14.5. Vehicle doors and platform doors shall be interlocked to prevent opening until all conditions for door opening have been satisfied (see Design Criteria Ch 14, Section 14.4.8). The platform doors shall meet the safety and performance requirements specified for the vehicle doors in Design Criteria Ch 14, Section 14.5.3 and Section 14.2.8 and in TP Sections 4.6.20, 4.7.8.2 through 4.7.8.65, and 4.7.8.9.

3. Variable Message Signs and the Public Address System shall provide audio and visual warning indicating the imminent departure and commencement of door closing. The departure warning shall be made approximately four (4) seconds before doors begin to close and shall be communicated to passengers both in the trains and on the platform.

4. Manually opening a station platform door shall result in an alarm being sent to Central Control. If any platform door is unlocked and/or open, trains shall be prohibited from entering or leaving that station. If any platform door is unlocked and/or opened while a train is entering the station area, the vehicle shall stop immediately using emergency brakes. For such condition emergency brakes shall be reset only by local manual reset and not remotely. See Design Criteria Ch 14, Section 14.5.2 and Section 14.5.3 for additional station door safety requirements. Emergency doors provided for egress from misaligned trains shall also meet all requirements of this paragraph.

5. In accordance with ASCE 21.3-08, Section 10.2 Platform Edge Protection, for any conditions where passengers can extend limbs or digits through windows or other openings of the vehicle, the means of platform edge protection shall be analyzed for any hazards in accordance with Hazards Identification, Analysis and Resolution process specified in TP Section 3.2.9.4.

6. A programmed station stop is the control of train speed and final application of brakes, under jerk and acceleration limits, to make a precise station stop. Programmed station stops shall be made so that the centerlines of the train doors and the corresponding station platform doors are aligned to within six (6) inches of each other. Misalignments shall not occur for more than one percent (1%) of all station stops. Parking or friction brakes shall apply when zero speed is detected and remain applied until the vehicle is ready to depart the station.
7. Whenever the train doors and station stopping points are not properly aligned as specified in the previous paragraph, but portions of the vehicle doorways are within the station platform doorway openings and at least a 32.5 inch clear opening is provided and where the opening is only onto the platform, the doors shall open automatically and an alarm shall be sent to Central Control. This alarm shall indicate the misalignment and identify the train and station involved. At the conclusion of the specified dwell time, the train doors shall close and the train shall automatically depart the station.

8. For all other misalignments, the train shall remain at the station with all doors remaining closed until a decision is made by the CCO regarding the disposition of the train. During this time, it shall not be possible to open the doors remotely by CCO command. Automatic announcements shall be made on the train and in the station involved. Maintenance personnel may, at the option of the CCO, perform opening of the train doors and exiting of passengers manually. When dispatched by the CCO, the train shall depart to the next station.

9. Any train jog movements implemented in the Supplier's design to allow recovery from an initially missed position station stop shall comply with the requirements of TP Section 11.1.10. Such maneuver shall be invoked only upon remote command from the CCO and the moves accumulated by one or more successive jog commands shall not collectively exceed four (4) feet of reverse direction distance. Jog maneuvers shall not be considered to satisfy the one percent (1%) station stop misalignment limit specified above.

10. Power required to operate the Platform edge barrier walls, including doors and other wall-mounted equipment such as communications equipment, is an additional Essential Power Load and shall be connected to emergency power systems in all passenger stations. Demand shall be 100 percent for the purposes of sizing emergency power system.

B. ATC-specific requirements

Operation of train and any platform doors shall meet the following requirements:

1. Platform doors shall be automatically controlled by the ATO except when a train is under local manual control. In that case, under ATP protection, the platform doors shall open and close in tandem with the vehicle doors when the vehicle doors are commanded by the OCC operator.

2. An ATP function shall be implemented such that it shall not be possible for the ATO to automatically open any Platform doors anywhere in the system except when the train is properly stopped and aligned at a station platform or transfer zone. Further, it shall not be possible to automatically open any train doors unless the doors are properly aligned adjacent to a station platform door, or boarding/discharging zone, to permit the safe egress of passengers. See Design Criteria Ch 14, Section 14.5.2.

3. Train doors and any corresponding platform doors shall be controlled as a set. Each such door set shall open and close as a coordinated movement when signaled to do so by the ATO subsystem. It shall not be possible to automatically open any train doors unless there are corresponding platform doors to comprise a complete and functioning door set.
4. The train doors and corresponding automatic platform doors shall be commanded to open automatically only after the successful completion of a programmed stop at a station in accordance with Design Criteria Ch 14, Section 14.4.8. At the end of the station dwell period, all train and corresponding automatic platform doors shall be commanded to close, unless a door hold command has been issued through the ATS subsystem.

5. All platform doors shall include obstruction detection hardware and operate in accordance with TP Section 4.7.8.3. The unobstructed door sets at the platform shall not be recycled.

6. If for any reason any platform door fails to open or close as commanded, an alarm shall be sent to the OCC. Corrective and/or maintenance action shall then be initiated in accordance with Design Criteria Section 14.5.3.D.

7. Unscheduled Door Opening Protection - The ATP subsystem shall ensure that no automatic mode failure shall result in the unlocking or opening of a platform door.

8. Door Control Protection shall include an ATP function that provides detection for any doors at the platform are unlocked or open, and if so ensues that the train’s speed reduces to brake positively just outside the platform where the detection occurred. Trains that are predicted to be affected due to this stoppage shall be held upon their arrival at their respective closest platform.

9. If any automatic station platform door, station emergency egress door or gate is unlocked for any reason, or if anyone is detected by any ATC-connected means to be on the guideway, trains shall be prohibited from entering or leaving that station platform. If any station emergency door or gate is unlocked for any reason, that trains shall emergency brake to a stop. For such conditions, brakes shall be reset only by local manual reset. Remote reset by OCC shall not be permitted.

10. For any unscheduled platform door, station emergency egress door, or gate unlocking or opening, regardless of the cause, a local alarm shall sound and an alarm shall be automatically annunciated at the OCC indicating that this emergency condition has occurred.

11. For all instances described by Items 8 to 10 in this list, only local manual reset shall be permitted. Remote reset by the OCC shall not be permitted. Restart shall not be permitted until all doors (vehicle and/or station) are properly closed and locked and a local check by system staff ascertains that no person is on the guideway.

12. Vehicle/Station Alignment and Door Interlocks - The ATP subsystem shall ensure that automatic opening of train doors and matching station platform doors shall occur only after all of the conditions of vehicle door opening listed in Design Criteria Ch 14, Section 14.4.8 have been satisfied.

13. Train-station misalignment or failure of doors to open shall initiate the actions required in Design Criteria Ch 14 Section, 14.5.2 and Section 14.5.3.

14. Departure Interlocks - The ATP subsystem shall ensure that a train stopped in a station shall not be allowed to move unless all platform doors are properly closed and locked and the train brakes have been released.

15. The following shall be considered a Priority 1 alarm as presented in TP 3.3.3:
a. Unscheduled platform door unlocking or opening, including emergency door/exit.

16. The following shall be considered Priority 2 alarms as presented in TP 3.3.3:
   a. Platform doors failed to open within ten seconds after train stops.
   b. Platform doors failed to close and/or lock when commanded.
   c. Platform doors recycled three times or obstructed for more than ten seconds.

PART 3 – EXECUTION

3.01 INTERFACE REQUIREMENTS

A. General:
   1. Responsible for ensuring that interface requirements are clearly identified.
   2. Do not presume any obligation on the City except where unequivocally agreed to and recorded in writing.
   3. Responsible for the running, securing, and termination of wires and cables to other equipment or systems that interface to the Train Control system.

B. Compatibility:
   1. The Train Control system shall be fully compatible with all systems and equipment provided as part of the overall project.
   2. The Train Control system shall be fully compatible with and shall not interfere with other HDOT infrastructure and systems.

C. Switch Machine and Layout: Provide support and the expertise to properly install the switch machines that are supplied MSF DB Contractor and installed by the guideway contractor. Along with the City, provide coordination and integration with these other two contractors for all switch machines in time for the system testing. Provide the control and indication wiring with all associated cabling and junction boxes. All locks, such as motor, detector compartments and crank cover, and lettering and numbering for the identification for the switch machine shall be provided. Once the installation is complete, verify and accepted mechanically, be responsible for all mechanical and electrical adjustments to result in the machine’s proper operation with the integrated Train Control system.

D. Power Supplies:
   1. Derive main power supplies for the Train Control system from the local supply at each station and the MSF. Derive supplies at stations from the standby UPS supply provided at each station. On the wayside, be responsible for power distribution to Train Control equipment and shall identify locations where main power supply connections are to be made throughout the system.
   2. If the Contractor selects to use the power is derived from the Electrification system, ensure that the supply is satisfactory for supplying the Train Control system, under all conditions of varying load, emergency feeding.
3. The provision of transformers, switchgear, and protection arrangements shall be the responsibility of the Contractor.

4. The distribution of power supplies from main power supply points throughout the Train Control system and equipment including wayside equipment rooms, and apparatus cases shall be the responsibility of the Contractor. Since the City is responsible for incoming power, submit information during the entire design process in this respect including, but not limited to, the following:
   a. Distribution voltage
   b. Maximum voltage drop in distribution conductors
   c. Protection arrangements, lightning, and grounds
   d. Isolation arrangements
   e. Contingency allowances
   f. Spare capacity

5. Provide for each supply point:
   a. The maximum continuous load
   b. The maximum peak load and its permitted duration
   c. The maximum and minimum voltage tolerances
   d. The maximum and minimum frequency tolerances

6. Note that provision of three phase supplies may be restricted to station areas only and be responsible for obtaining three-phase power from the station’s source.

7. Should the supply available not comply with the Contractor’s tolerances it shall be the Contractor’s responsibility to condition the power supply to acceptable levels.

8. If such conditioning is incorporated, state how the reliability of the conditioning equipment has been taken into account in preparing reliability and availability statistics.

9. Submit details of the proposed arrangements for changeover both between the main and standby supplies and vice versa. The details shall explain how the system availability is maintained while the changeover takes place.

10. At the OCC, a secure supply (main supply plus a standby supply) will be supplied for use of the Contractor.

11. Where back-up supplies are not provided by others, provide a backup supply with two hour duration at stations and MSF.

12. Where batteries are used these shall be sealed, maintenance-free, robust, rechargeable cells, and shall have terminals to which bolted connections shall be made. Provide the City details of battery types and their Design Life.

13. Comprehensive alarm and indication facilities shall be provided to alert OCC Train Controllers and maintenance staff to the status of power supplies, and to indicate failure of the main or standby power supply systems.

E. Civil Engineering Requirements:

1. Structure Gauge:
a. Signaling equipment shall be installed in accordance with, and shall not infringe, the structure gauge.

b. Where signaling equipment is in close proximity to the structure gauge (within 100 mm), it shall be the responsibility of the Contractor to ensure that the construction gauge has not been infringed.

2. Buildings and Structures:
   a. Submit details of its requirements for small equipment rooms (e.g. housings, cases) shall be provided by the Contractor.
   b. Provide air conditioning, lighting and firefighting equipment in the small equipment rooms and cases supplied.
   c. The City will provide permanent equipment rooms at all stations for the Contractor’s use. At each temporary terminal station, wherever practical, design equipment placement such that the temporary equipment can be removed to free its space.
   d. The design of the equipment for line extensions shall readily accommodate such relocation with minimum disruption.
   e. Where equipment is to be located in housings or cases, on guideways, in stations, or in other of the City’s buildings, all designs for foundations, mountings and fixtures shall be fully integrated with the City’s design and architectural requirements. These housing(s) shall include the environmental equipment sized to support the equipment. The design shall include the interface to the MSF ductbank or cable trough. For each case, be responsible for the following:
      1) Defining the location
      2) Defining the complete mechanical loading of each mounting
      3) Defining the design of foundation, mounting and fixture arrangements
      4) Electrical and grounding requirements
      5) The use of the city provided Cable routes and Duct back requirements; otherwise add cable routes at your own cost
      6) Liaison with the City on design and architectural integration

F. Trackwork Requirements:
   1. Switch Machines: In respect with the switch operating mechanisms, coordinate the requirements of connections to such mechanisms on the switch layout design. Cooperate with the City and all other contractors to integrate the respective designs.
      a. Gauge plates may be required or desirable for purposes of the Train Control system and maintaining accurate displacement between the switch and the switch machine and to resist the forces applied by the power switch machines when throwing and closing the switch rails against the stock rails. The Contractor responsible for the procurement of the special trackwork and the fabricator of that special trackwork will coordinate with the below-listed other contractors, subcontractors and vendors so as to assure that the design is fully integrated and structurally sound.
         1) The manufacturer(s) of the yard and mainline switch machines.
         2) The trackwork installer(s) of the ballasted and direct fixation track turnouts.
3) The Contractor or subcontractor of these requirements for the Train Control system shall provide installation expertise to complete and assure proper operation of all switch machines.

4) Others as appropriately requested through the City.

b. Where gauge plates are proposed to accommodate end-butted switch ties in crossovers, details will be shown on shop drawings and assembly drawings.

2. IJs: Detail requirements for the provision of IJs. Submit full details in respect of the following:
   a. Location of IJs
   b. Estimated quantity of IJs
   c. Technical constraints
   d. Electrical performance requirements

3. Bond Connections:
   a. Where bonding is to be connected to rails for track circuit, grounding or train control purposes, methods of connection shall be such as to reliably withstand the track/rail environment and shall ensure that:
      1) Rail life expectancy is unaffected
      2) Physical properties of the rail are unaffected and premature rail failure avoided
      3) Rail fatigue detection and maintenance methods are unaffected.
   b. Submit full details of methods used, together with evidence of performance of processes and connections.

G. Vehicle Interface:

   1. A partial of the Vehicle input/outputs to the ATC equipment are listed in Technical Provision TP-04, “Passenger Vehicle”. Submit full details of its listing to accomplish this interface, together with the description of each point and connections.

   2. Signal Sighting: If wayside signals are required, ensure that all fixed wayside signals (for both MSF and mainline) shall be visible by the operator at an adequate distance. Take into account the rolling stock requirements to ensure that all factors relating to visibility of signals and marker boards from all vehicles (including maintenance vehicles) have been addressed. These factors shall include, but are not limited to, the following:
      a. Sight line through vehicle window from all possible positions of operator’s eye level when approaching and when stopped at a Stopping Point or signal. This shall include consideration of the distance in rear of the signal at which the operator must stop the train in order to keep the object in sight.
      b. Visibility of signal in expected weather and light conditions, taking account of tinting or coating on the windscreen glass.
      c. Lights on the train.
      d. Speed and distance at which the object is required to be seen.
      e. Trains approaching on opposite track.
      f. Track curvature and wayside fixtures.
3. Braking Performance: Ensure that the service and emergency braking distances and braking profiles, and other braking characteristics of all rolling stock (including ancillary vehicles) are used to determine Block Section length and spacing, and that the required Signaling and Operational Headways can be achieved. The factors to be taken into account shall include, but are not limited to, the following:
   a. Running with dynamic brake isolated
   b. Running with permitted number of brakes isolated
   c. Worst case adhesion
   d. All gradients
   e. All Line Speeds

4. Propulsion Performance: Ensure that commands are exchanged with the vehicles propulsion modules for speed regulation and acceleration regulation for schedule algorithms.

5. Wheel Detection by Axle Counter: Ensure that the wheels of all vehicles (including maintenance vehicles) will be detected correctly by the type of axle counter, and shall take account of the vehicle requirements to ensure that all factors relating to detection of a wheel by an axle counter have been addressed. These factors shall include, but are not limited to, the following:
   a. Wheel profile (new and worn)
   b. Maximum speed
   c. Dynamic position of flange with respect to rail

6. Driverless ATC: Take account of the vehicle requirements for recovery scenarios ensures that all factors relating to the visibility of the Driverless ATC system display and the operation of the Driverless ATC system controls in all vehicles (including maintenance vehicles) have been addressed. These factors shall include, but are not limited to, the following:
   a. Visibility of display and controls in expected weather and light conditions, taking account of tinting or coating on the windscreen glass
   b. Accessibility and ease of use of controls

7. Positional Control of On-Board Equipment: Take account of the vehicle requirements to ensure that all requirements for positional control of equipment on board the train have been catered for, where this control is to be effected by data available from the Driverless ATC system. This may include, but is not limited to, the following:
   a. Correct positioning of train within the platform limits
   b. Correct side door opening and closing at platforms
   c. Disabling doors not in platforms
   d. Passengers information systems (triggering announcements or displays on approach to stations)

8. Wheelset Impedance: Confirm that the electrical impedance of each wheelset from wheel surface to wheel surface at the frequency of operation of any track circuits is sufficiently low to operate them reliably. The factors to be taken into account include, but are not limited to, the following:
   a. Electrical bonding around bearings
   b. Traction return current bonding on the vehicle
9. Electromagnetic Interference (EMI):
   a. Ensure that EMI emanating from the train both in the form of radiated energy and interference present in the traction supply return current, shall not cause failure of track circuits, axle counters, Switch Machine or detectors, or Driverless ATC links. The factors to be taken into account include, but are not limited to, the following:
      1) Frequencies generated by the Electrification system and Traction Power systems and auxiliary supply systems of Consists or vehicles in normal and failure conditions
      2) Transient effects resulting from transformer inrush
      3) Traction return current passing through the rails
      4) Longitudinal voltage presented between adjacent wheelsets
      5) The effects of asymmetrical operation of the train power systems
      6) Sensitivity, coding, and frequency range of track circuits
      7) Spacing of electrification track-to-track crossbonding
   b. (Note: Immunity from 60Hz is covered in Article 1.05A.7 herein).
   c. Demonstrate that EMI from the train will not cause a Wrong-side Failure of any part of the Train Control system.

H. Other administrations: Ensure that electrical interference from other transportation systems does not cause failure of any Train Control system, with particular reference to track circuits. The factors to be taken into account include, but are not limited to, the following:
   1. All wayside systems and track circuits
   2. External transit systems
   3. EMI from other transportation systems, i.e., airports, shipping
   4. Bonding between systems

I. Other Core System Disciplines: The Contractor is responsible for all interfaces between the Train Control and all the other Core system disciplines. Optimize the use of shared facilities where it is possible without compromising performance, safety, reliability, or maintainability.

3.02 DESIGN PROCESS

A. This Section deals with the design process requirements of the Contractor and the City in relation to the processes of this Contract that are beyond the requirements laid down for quality assurance and describes the system acceptance stages.

B. Contractor’s Design Checking:
   1. All design and details produced shall be fully checked.
   2. The design checker shall have no direct involvement in the design production. To achieve this level of independence the original producer shall not under any circumstances seek guidance from or consult with the checker, even on matters of general principle.
   3. The design checker shall establish that when implemented the design is:
a. Safe
b. Will work
c. Interfaces correctly with all other facilities and systems
d. Meets these Train Control Requirements

4. Design check certification shall separately identify:
   a. Train control principle requirements
   b. Application-specific requirements (e. g. control tables to plan, wiring and data
ten control tables)
   c. Physical requirements (e. g. equipment profiles, terminal analysis)

5. All Technical Documentation produced during the design process shall be retained
   by the Contractor until advised by the City that it is not necessary to do so.

C. City’s Design Review:

1. The City shall at any time, prior to the agreed disposal of documentation, be afforded
   at its convenience the opportunity to examine, review, and comment on all design
   documentation. At a minimum, three design reviews shall be performed at a mutual
   agreed stage of the design process. The three design reviews are the initial Definitive
   Design, the Interim Design Review and the Final Design Review. Recognize and
   accommodate the activities of an independent design checker nominated by the City.
   These activities will include independent verification and validation of the design.
   Responsible for all changes incurred in undertaking the review.

2. Make available to the City, as and when required, reference material applicable to the
   design. This requirement shall be irrespective of whether or not such material has
   been directly used by the individuals undertaking the design production and design
   checking.

3.03 INFORMATION REQUESTED FROM CONTRACTOR

A. Provide submissions to fully document the Train Control system to be supplied.

END OF SECTION