READ THIS FIRST

Notice to the Design Engineer, this document is part of Facilities and Infrastructure standards for Electrical Systems. Designers are advised to NOT use this template (*.doc) document as part of any project contract documents. Designers shall use the Port of Seattle MasterSpec specifications from the following link:

https://www.portseattle.org/page/guide-specifications.

Designers shall edit the corresponding Port's MasterSpec specification to meet the F&I Electrical Standard outlined in this specification. Note that Port's MasterSpec specifications contain specifications and languages for both Aviation and Maritime Divisions. F&I Standards are strictly for Aviation Division, and any Maritime related specs or languages should be removed from the project specifications.

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY AND NOTES TO DESIGNER

A. Section includes secondary unit substations, each consisting of medium-voltage primary incoming section, transformer section, and low-voltage secondary switchgear section, with the following features:

1. Indoor and outdoor enclosures.
2. Medium-voltage, metal clad and metal enclosed primary load-interrupter switch section.
3. Liquid-filled and Dry-type transformers.
4. Secondary distribution section.
5. DC system including batteries. Battery systems are not required on all secondary unit substations. Coordinate requirement with F&I.

B. The typical configuration for power centers is double ended switchgear. Each end includes a medium voltage compartment with load interrupter switch and surge arrestor, a medium voltage-to-low-voltage transformer (dry type for indoor installations, oil filled for outdoor installations), and a low voltage switchgear section with draw-out circuit breakers. The two low voltage sections are connected with a tie-breaker.

1. The unit substation shall have cube spaces reserved for meters.
2. The main breakers shall be metered with Eaton PQM series.
3. The feeder breaker shall each have an Eaton PEM series depending on the load. Coordinate with F&I.

C. Use of single-ended primary selective unit substations with a single transformer requires F&I approval.

1. If single-ended type unit substations are used, make provisions for expansion of the low-voltage switchgear.

D. Coordinate requirements for metering and protective relaying of medium voltage components of unit substation. Metering and relaying is typically done at the 480V distribution level.

E. Coordinate with F&I on requirement for battery system. Not all unit substations require battery systems – this will be determined on a case-by-case basis.

F. Transformers: Dry type for indoor installations, liquid filled for exterior applications.

1. Unit substation type service transformers should be avoided outdoors due to higher cost and difficulty of maintenance. Refer to Dry Type Transformer Article for information on transformers for indoor unit substations.
2. For liquid filled transformers, for units rated less than 1500 kVA, cooling per engineering requirements, but typically OA/FA/FA.

G. Circuit Breakers: Mechanical Interlocking: Uses a mechanical tripping lever or equivalent design and electrical interlocks where required by engineering design.

1. The Port does not recommend Fused Circuit breakers, but can be used where required by engineering considerations.

H. Meters: Meters are typically installed in spare cube spaces on the top row of the switchgear. For the main circuit breakers, specify Eaton PQM series. For feeder breakers, specify Eaton PEM series depending on the load being fed. Refer to Section262713 – “Electrical Power Metering”.

I. For indoor installations, the room in which the unit substation is housed shall have the following:

1. Fluorescent lights with lens, wireguard and low-temperature ballasts and controlled by wall switch at each entrance. Lighting level minimum 70 footcandles at normal power and 40 footcandles emergency.
2. GFCI duplex receptacles, a minimum of two.
3. Electric unit heater(s), wall or ceiling mounted, with integral thermostat and disconnect and with capacities to maintain switchboard interior temperature of 50 deg F with outside design temperature of 21 deg F.
4. Exhaust fan with capacities to maintain switchboard interior temperature of 85 deg F. with outside design temperature of 104 deg F.
5. Supply fan for filtered air to pressurize aisle to 0.1 inches water compared to outside.
6. Ventilating openings complete with replaceable fiberglass air filters.
7. Thermostat: Single stage; wired to control heat and exhaust fan.

J. Secondary Distribution Section Network Protectors are not standard on unit substations at the airport. Consult with F&I to determine if needed.

K. Existing low voltage drawout circuit breakers: Where modification is made to existing breaker settings, provide breaker test for modified breaker.

L. Related Requirements:

1. Section 260513 "Medium-Voltage Cables" for requirements for terminating cables in incoming section of substation.

1.3 DEFINITIONS

A. BIL: Basic insulation level.

B. MCC: Motor-control center.

C. MVA: Megavolt ampere.

D. NETA ATS: Acceptance testing specification.

E. PCB: Polychlorinated biphenyl.

F. RTD: Resistance temperature device.

G. SCR: Silicon-controlled rectifier.

H. VRLA: Valve-regulated lead acid.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Three-line Wiring Diagrams: Power, signal, and control wiring.
   a. Differentiate between field installed and manufacturer installed wiring.
2. Dimensioned plans and elevations showing major components and features.
   a. Include a plan view and cross section of equipment base, showing clearances, manufacturer's recommended workspace that accounts for breaker service and removal, and locations of penetrations for grounding and conduits.
3. Cable termination information.

4. Conduit entry and exit information.
5. One-line diagram.
6. List of materials.
7. Nameplate legends.
8. The material, size and number of bus bars, and current rating for each bus, including mains and branches of phase, neutral, and ground buses.
9. Short-time and short-circuit current ratings of secondary unit substations and components.
10. Ratings of individual protective devices.
11. Mimic-bus diagram.

C. Time-Current Characteristic Curves: For overcurrent protective devices.

D. Primary Fuses: Submit recommendations and size calculations.

1. Utility company's metering provisions with indication of approval by utility company.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings for Outdoor Installations:

1. Utilities site plan, drawn to scale, showing heavy equipment or truck access paths for maintenance and replacement.

B. Coordination Drawings for Indoor Installations:

1. Location plan, showing heavy equipment or truck access paths for maintenance and replacement.
2. Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved.
3. Dimensioned concrete base, outline of secondary unit substation, conduit entries, and grounding equipment locations.
4. Support locations, type of support, and weight on each support. Locate structural supports for structure-supported raceways, busways, and seismic bracing.
5. Location of lighting fixtures, sprinkler piping and heads, ducts, and diffusers.

C. Qualification Data: For testing agency.

D. Seismic Qualification Certificates: For transformer assembly, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity, and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Product Certificates: For secondary unit substations, signed by product manufacturer.

F. Factory test reports.

G. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For secondary unit substations and accessories to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Standby Fuses in separate enclosure: Six of each type and rating of fuse and fusible device used, except for medium-voltage fuses and fuses associated with network protector. Include stand-by fuses for the following:
   a. Primary disconnect fuses.
   b. Potential transformer fuses.
   c. Control power fuses.
   d. Fuses and fusible devices for fused circuit breakers.
   e. Fuses for secondary fusible devices.
2. Standby Indicating Lights in a parts enclosure: Three of each type installed.
3. Touchup Paint: One pint container of paint matching enclosure's exterior finish packaged with protective covering for storage and identified with labels.
4. Primary Switch Contact Lubricant: One container.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA or the National Institute for Certification in Engineering Technologies to supervise on-site testing.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver in shipping splits in sizes that can be moved past obstructions in delivery path.

B. Coordinate delivery of secondary unit substations to allow movement into designated space.

C. Store switchgear indoors in clean dry space with uniform temperature to prevent condensation. Protect switchgear from exposure to dirt, fumes, water, corrosive substances, and physical damage.

D. If stored in areas subjected to weather, cover switchgear to provide protection from weather, dirt, dust, corrosive substances, and physical damage. Provide temporary heating according to manufacturer's written instructions.

E. Handle secondary unit substation components according to manufacturer's written instructions. Use factory-installed lifting provisions.

F. Ship with accelerometers: 0.3gs in the x, 0.9gs in the y and z direction.

1.10 FIELD CONDITIONS

A. Service Conditions: The unit substation shall be suitable for operation under service conditions specified as usual service conditions in IEEE C37.121, except for the following:

1. Exposure to significant solar radiation.
2. Altitudes above 1000 feet.
3. Exposure to fumes, vapors, or dust.
4. Exposure to seismic shock or to abnormal vibration, shock, or tilting.
5. Unusual space limitations.

B. Project Conditions- Existing Utilities: Do not interrupt utilities serving facilities occupied by the Port or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify Port of Seattle Resident Engineer not less than seven days in advance of proposed utility interruption.
2. Do not proceed with utility interruptions without Port of Seattle Project Manager’s or Construction Manager’s written permission.
3. Coordinate with requirements specified in Section 01500 Temporary Facilities and Controls for temporary utilities.
4. Field measurements: Verify dimensions by field measurements.

1.11 WARRANTY

A. Manufacturer shall offer a single warranty covering all substation assemblies, transformers and components.

B. Manufacturer's Special Warranty: Manufacturer agrees to repair or replace components of the dc system battery equipment that fail(s) in materials or workmanship within specified warranty period. Special warranty, applying to batteries only, applies to materials only, on a prorated basis, for period specified.

1. Warranty Period: Include the following warranty periods, from date of Substantial Completion:
   a. DC System Equipment (excluding Batteries): Twenty year(s).
   b. Standard VRLA Batteries:
      1) Full Warranty: Three year(s).

2) Pro Rata: Five years.

1.12 SOURCE QUALITY CONTROL

A. Test according to IEEE C37.20.2.

B. Make completed switchgear available for inspection at manufacturer's factory prior to packaging for shipment. Notify the Port at least two weeks before inspection is allowed.

C. Allow witnessing of factory inspections and tests at manufacturer's factory or test facility. Notify the Port at least two weeks before inspections and tests are scheduled.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. EATON Corporation, no exceptions;

2.2 SYSTEM DESCRIPTION

A. Description: Medium-voltage, double ended primary incoming section; transformer section; and low-voltage secondary switchgear section; and including coordinated circuit breakers and tie breakers, fusible switches, and metering components. Dual indoor or airfield application dry type, OR outdoor liquid filled transformers.

B. Provide copper bus, cable and connectors. No aluminum bus, cable or connectors will be allowed.

C. The manufacturer of the unit substation shall furnish and coordinate all major components of the substations as a single contiguous unit, including incoming primary equipment section, transformer and low-voltage section as well as circuit-breakers, fusible switches and metering components.

1. Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with IEEE C2.
3. Comply with IEEE C37.121.
4. Comply with NFPA 70.

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: The secondary unit substations shall withstand the effects of earthquake motions determined according to ASCE/SEI **7.**

1. The term "withstand" means "the secondary unit substation will remain in place without separation of any parts when subjected to the seismic forces specified and the secondary unit substation will be fully operational after the seismic event."

2.4 MANUFACTURED UNITS

A. Indoor or Outdoor Unit Arrangement: Single assembly.

1. Outdoor unit:
   a. Weatherproof, listed for installation outdoors, complying with IEEE C37.20.1.

B. Connections between the primary device and transformer shall be copper bus, and between the transformer and secondary shall be flexible bus braid to copper bus.

C. Indoor Enclosure: Steel.

D. Outdoor Enclosure: Weatherproof, for outdoor service. Galvanized-steel, weatherproof construction; integral structural-steel base frame with factory-applied asphaltic undercoating.

1. Enclosure: Downward, rearward sloping roof; rear hinged doors for each section, with provisions for padlocking.
2. Each compartment shall have the following features:
   a. Structural design and anchorage adequate to resist loads imposed by 125-mph wind.
   b. Space heater operating at one-half or less of rated voltage, sized to prevent condensation, controlled by thermostats to maintain temperature of each section above expected dew point.
   c. Louvers equipped with insect and rodent screens and filters, and arranged to permit air circulation while excluding rodents and exterior dust.
3. Weatherproof internal-aisle construction shall have the following features:
   a. Common internal aisle of sufficient width, to permit protective device withdrawal, disassembly, and servicing in aisle, 42 inches minimum.
   b. Doors: Personnel door at each end of aisle, minimum width of 30 inches; opening outwards; with panic hardware and provisions for padlocking.
   c. Aisle space heaters operating at one-half or less of rated voltage and thermostatically controlled.
   d. Fluorescent aisle lights with lens, wireguard and low-temperature ballasts and controlled by wall switch at each entrance. Lighting level minimum 70 footcandles at normal power and 40 footcandles emergency.
   e. Emergency battery pack lighting fixture installed on wall of aisle midway between personnel doors.
   f. GFCI duplex receptacles, a minimum of two, located in aisle.
   g. Factory-installed electric unit heater(s), wall or ceiling mounted, with integral thermostat and disconnect and with capacities to maintain switchboard interior temperature of 50 deg F with outside design temperature of 21 deg F.

h. Factory-installed exhaust fan with capacities to maintain switchboard interior temperature of 85 deg F. with outside design temperature of 104 deg F.
i. Supply fan for filtered air to pressurize aisle to 0.1 inches water compared to outside.
j. Ventilating openings complete with replaceable fiberglass air filters.
k. Thermostat: Single stage; wired to control heat and exhaust fan.

E. Skid Mounted: Mount each shipping group on an integral base frame as a complete weatherproof unit.

F. Unit Substation Enclosures Finish:

1. Indoor Applications: Factory-applied finish in manufacturer's standard gray.
2. Outdoor Applications: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

2.5 MEDIUM-VOLTAGE TERMINAL COMPARTMENT SECTION

A. Primary Incoming Section: Terminal assembly with adequate space for incoming-cable terminations and surge arresters, complying with NEMA SG 4 and meeting thermal, mechanical, and dielectric requirements specified for the transformer section.

B. Ratings: Suitable for application in three-phase, 60-Hz, solidly grounded-neutral system.

C. System Voltage: 12.5kV.

D. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, connected in each phase of incoming circuit and ahead of any disconnecting device.

E. Infrared Windows: Provide windows on the front and back of the compartment section. Windows shall provide clear visual of termination points and bus bars.

2.6 MEDIUM-VOLTAGE METAL-CLAD SWITCHGEAR SECTION

A. Metal-clad, vacuum circuit-breaker switchgear, complying with IEEE C37.20.2 and NEMA SG 4 and tested for compliance according to NEMA C 37.55. See also Section 261300 “Medium Voltage Switchgear”.

1. Arc Resistant: Comply with IEEE C37.20.7, Type 1.

B. Nominal Interrupting Capacity Class: 250, 350, 500, 750, 1000 MVA.

C. Ratings shall comply with IEEE C37.04, suitable for application in three-phase, 60-Hz, solidly grounded-neutral system.

1. System Voltage: 4.16 kV nominal; 5 kV maximum OR 12.47kV nominal, 15kV maximum.

2. Nominal Interrupting-Capacity Class: 250, 350, 500, 750, 1000 MVA.
3. Main-Bus Rating: Minimum 2000 A, continuous.
4. Design Level of Available Source Fault Current: Integrated short-circuit rating consistent with available fault current indicated.

D. Circuit Breakers: Electrically operated, air-interrupter with drawout mounting and including the following features:

1. Maximum Voltage: 15kV or 5kV.
2. BIL Rated 95kV OR 60kV.
3. Continuous Current Rating of Feeder Circuit Breaker: 1200A OR 2000A.
4. Short Circuit Current at Rated Maximum kV: 18, 28 37 kA RMS.
5. Closing and Latching Capability: 62, 97, 130 kA Crest.
6. Three Second Rating: 23, 36, 48 kA.
7. Designed to operate at rated voltage to interrupt fault current within its rating within three cycles of trip initiation. For systems with X/R ratio of 17 or less, transient voltage during interruption shall not exceed twice the rated line-to-ground voltage of the system.
8. Contact-Wear Indicator: Readily accessible to field maintenance personnel.
9. Minimum of six spare auxiliary contacts.
10. Interchangeability: Interchangeable with circuit breakers of same current and interrupting ratings.
11. Operating Mechanism: Electrically charged, mechanically and electrically trip-free, stored-energy operation.
    a. Closing speed of moving contacts to be independent of both control and operator.
    b. Design mechanism to permit manual charging and slow closing of contacts for inspection or adjustment.
12. Provide at least two spare breakers and two equipped spaces for each bus.
13. Provide one 3200 ampere and one 1200 ampere frame breaker carriage.

E. Vacuum Circuit Breakers: Draw-out mounted units using three separate vacuum sealed contact modules.

1. Circuit breaker operates at rated voltage to interrupt fault current within three cycles of trip initiation.
2. Contact-wear indicator readily accessible to field maintenance personnel.

F. Control Power:

1. 48V OR 125V OR 250V DC for closing and tripping.
    a. Each breaker to be complete with control switch and red, green and amber indicating lights to display the state of each breaker (open, closed, tripped) and an annunciator with provisions for resetting alarm. Annunciator shall have provisions for remote annunciation.
    b. Circuit Breaker Tripping Provisions: Furnish at least 3 multi-ratio CTs for each feeder breaker, Class 0.2 accuracy minimum.
    c. Provide shunt trip capability independent of overcurrent trip.
    d. Low-DC-Voltage Alarm: Monitor dc control power voltage with a remote alarm. Alarm shall sound if voltage falls to an adjustable value to indicate an

impending battery failure. Factory set alarm value at 80 percent of full-charge voltage.

G. Circuit-Breaker Test Cabinet:

1. Separately mounted.
2. Containing push buttons for circuit-breaker closing and tripping, control relay, fuses, and secondary coupler with cable approximately 108 inches long.
3. Include secondary devices for operating circuit breaker if removed from switchgear and moved near test cabinet.
4. Include provision for storage of test and maintenance accessories in cabinet.

H. Surge Arresters: Comply with IEEE C62.11 and NEMA LA1, Distribution Class or better; metal-oxide-varistor type.

1. Incoming Line Main Circuit Breakers: Provide suitably rated connected in each phase of circuit and grounded to the metal structure, for each incoming line.
2. Feeder Breakers: Where required, provide suitably rated utility grade MOV type, connected in each phase of circuit and grounded to the metal structure for each feeder section.

I. Maintenance Tools: Furnish tools and miscellaneous items required for circuit-breaker test, inspection, maintenance, and operation.

1. Fuse-handling tool.
2. Extension rails, lifting device, transport or dockable dolly or mobile lift, and all other items necessary to remove circuit breaker from housing and transport to remote location.
3. Racking handle to move circuit breaker manually between "connected" and "disconnected" positions, and a secondary test coupler to permit testing of circuit breaker without removal from switchgear.

J. Infrared Windows: Provide windows on the front and back of the compartment section. Windows shall provide clear visual of termination points and bus bars.

2.7 MEDIUM-VOLTAGE INSTRUMENTS SECTION

A. Instrument Transformers: Comply with IEEE C57.13.

1. Potential Transformers: Secondary voltage rating of 120 V and NEMA C 12.11Accuracy Class of 0.3 with burdens of W, X, and Y.
2. Current Transformers: Burden and Accuracy Class suitable for connected relays, meters, and instruments.
3. Compatible with EATON PQM and PEM series meters

B. Multifunction Digital-Metering Monitor: Microprocessor-based revenue-grade unit, 0.5% accuracy in compliance with WAC and RCW. Remote monitoring over Ethernet TCP/IP backbone. Suitable for three- or four-wire systems.

1. EATON PQM/PEM series as specified in Section 262713 “Electrical Power Metering”.

2.8 BATTERY SYSTEM

A. System Requirements: Battery shall have number of cells and ampere-hour capacity rating as required for design. Cycle battery before shipment to guarantee rated capacity on installation. Arrange battery to operate ungrounded.

1. One DC circuit breaker shall supply power to no more than one switchgear section.
2. Typically maintain float voltage of 2.25V per cell and equalize voltage of 2.38V per cell.

B. Battery: Gel lead-calcium type in sealed, clear plastic or glass containers, complete with electrolyte, fully charged and arranged for shipment with electrolyte in cells. Limit weight of each container to not more than 90 lb. and cells per container to not more than 3. System batteries shall be suitable for service at an ambient temperature ranging from 0°F to 90°F. Limit variation of current output to 0.8 percent for each degree below 77°F down to 0°F.

C. Rack: Two-step, non-conductive, acid-resistant rack sized to fit the available space with electrical connections between battery cells and between rows of cells; include two flexible connectors with bolted-type terminals for output leads. Rate battery rack, cell supports, and anchorage for seismic requirements**.**

D. Accessories:

1. Thermometers with specific-gravity correction scales.
2. Hydrometer syringes.
3. Set of socket wrenches and other tools required for battery maintenance.
4. Wall-mounting, nonmetallic storage rack fitted to store above items.
5. Set of cell numerals.

E. Charger: Static-type silicon rectifier equipped with automatic regulation and provision for manual and automatic adjustment of charging rate. Unit shall automatically maintain output voltage within 0.5 percent from no load to rated charger output current, with ac input-voltage variation of plus or minus 10 percent and input-frequency variation of plus or minus 3 Hz. Charger shall include the following features:

1. DC ammeter.
2. DC Voltmeter: Maximum error of 5 percent at full-charge voltage; operates with toggle switch to select between battery and charger voltages.
3. Ground Indication: Two appropriately labeled lights to indicate circuit ground, connected in series between negative and positive terminals, with midpoint junction connected to ground by normally open push-button contact.
4. Capacity: Sufficient to supply steady load, float-charge battery between 2.20 and 2.25 V per cell and equalizing charge at 2.33 V per cell and a maximum of 2.4Vpc.

5. Charging-Rate Switch: Manually operated switch provides for transferring to higher charging rate. Charger operates automatically after switch operation until manually reset.
6. Source AC power supply requirements are: 120 V, 60 Hz, subject to plus or minus 10 percent variation in voltage and plus or minus 3-Hz variation in frequency. After loss of ac power supply for any interval, charger automatically resumes charging battery. Charger regulates rate of charge to prevent damage due to overload and to prevent fuses or circuit breakers from opening.
7. Protective Feature: Current-limiting device or circuit, which limits output current to rating of charger but does not disconnect charger from either battery or ac supply; to protect charger from damage due to overload, including short circuit on output terminals.
8. Electrical Filtering: Reduces charger's audible noise to less than 26 dB.

2.9 LIQUID-FILLED TRANSFORMER SECTION

A. Description: IEEE C57.12.00 and C57.12.13 liquid-filled, two-winding, secondary unit substation transformer.

B. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. EATON
2. Square D
3. Cooper Industries

C. Ratings:

1. kVA Rating: 500kVA through 2500kVA.
2. Maximum kVA: Recommended maximum kVA for 3-phase transformers is 2000 kVA at 480/277V and 750kVA at 208/120V. Higher ratings require F&I approval.
3. Nominal Primary Voltage: 12.47 Delta OR 4.16kV Delta.
4. Nominal Secondary Voltage: 4,160Y/2400V, 3Ø, 4 wire OR480Y/277V, 3Ø, 4 wire OR 208Y/12V, 3Ø, 4 wire OR 120/240V, 1Ø, 3 wire.

D. Insulating Liquid: Less flammable, silicone-based or hydrocarbon mineral oil dielectric, and listed and labeled by an NRTL as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall have low toxicity and be nonhazardous.

E. Insulation Temperature Rise: 65 deg C, based on an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C.

F. BIL:

1. HV BIL: 95kV at 12.47kV OR 60kV at 4160V
2. LV BIL: 30kV

G. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps, two above and two below rated primary voltage; with externally operable tap changer for de-energized use and with position indicator and padlock hasp.

H. Cooling System: IEEE Standard C57.12.00, Class OA/FFA above 1500 kVA. Cooling systems shall include auxiliary cooling equipment, automatic controls, and status indicating lights.

I. Impedance: 2.2% to 5.75%, depending on kVA rating.

J. Bushing Mounting Arrangement: High-voltage and low-voltage bushings mounted on opposite sides of transformer.

K. Accessories: Grounding pads, lifting lugs, and provisions for jacking under base. Transformers shall have a steel base and frame allowing use of pipe rollers in any direction, and an insulated, low-voltage, neutral bushing with removable ground strap. Include the following additional accessories:

1. Lightning Arrestors: Utility grade Distribution type, connected to high-voltage terminals.
2. Surge Arrestors: Low voltage type, connected to low voltage terminals.
3. High Voltage Terminal Compartment: Full-height steel for side mounted terminals.
4. Low-Voltage Terminal Compartment: Full-height steel compartment.
5. One-inch globe type drain valve with sampling device.
6. Dial type thermometer.
7. Mounting provisions for low-voltage CTs and PTs, if required.
8. Liquid-level gauge.
9. Pressure-vacuum gauge.
10. Liquid temperature indicator.
11. Alarm contacts for above gauges.
12. Drain and filter valves.
13. Pressure-relief device.
14. Nameplates as required by Port.

2.10 DRY-TYPE TRANSFORMER SECTION

A. Description: NEMA Standard ST20, IEEE C57.12.01, IEEE C57.12.50 OR IEEE C57.12.51, and dry-type, two-winding, secondary unit substation transformer.

B. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:

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1. EATON
2. Square D
3. Cooper Industries

C. Style: Indoor, ventilated, cast coil/encapsulated coil, with primary and secondary windings individually cast in epoxy; with insulation system rated at 185 deg C with a 115

deg C average winding temperature rise above a maximum ambient temperature of 40 deg C.

D. Cooling System: Class AA/AA/FA, air cooled with provisions for future forced-air rating, complying with IEEE C57.12.01.

1. Automatic forced-air cooling system controls, including thermal sensors, fans, control wiring, temperature controller with test switch, power panel with current-limiting fuses, indicating lights, alarm, and alarm-silencing relay.
2. Include mounting provision for fans.

E. Insulation Materials: IEEE C57.12.01, rated 185 deg C.

1. Insulation Temperature Rise: 115 deg C, maximum rise above 40 deg C.

F. Ratings:

1. kVA Rating: 75kVA through 2500kVA. Recommended kVA for 3 phase transformers is 2500/3375/4500 kVA with temperature rise of 115°C/150°C/150°C at 480Y/277V, and 500 kVA at 208Y/120V. Higher ratings require F&I approval.
2. Nominal Primary Voltage: 12.47 kV Delta OR 4.16/12.47 kV Dual Voltage, Delta OR 4.16 kV Delta.
3. Nominal Secondary Voltage: 480Y/277V, 3 Ø, 4 wire, OR 208Y/120V, 3Ø, 4 wire OR 120/240V, 1Ø, 3 wire.

G. BIL:

1. HV: 95 kV at 12,470V OR 60 kV at 4160V.
2. LV: 30 kV.

H. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps, two above and two below rated primary voltage.

I. Impedance: 2.2%-5.75%, depending on voltage.

J. Sound Level Standards: Sound level standards as defined in NEMA and ANSI OR Low-sound level rating of 3 dB minimum less than NEMA TR standard sound levels - in noise sensitive areas.

K. Infrared Windows: Provide windows on the front and back of the compartment section. Windows shall provide clear visual of termination points and transformer coils.

L. Accessories:

1. External High Voltage Lighting Arrestors: Distribution type, low spark-over metal oxide varistor type.
2. External Low Voltage Lightning Arrestors: Metal oxide varistor type.
3. High Voltage Terminal Compartment: Full-height steel for side mounted terminals.
4. Low-Voltage Terminal Compartment: Full-height steel compartment.

5. High Temperature Alarm: Sensor at transformer with local audible and visual alarm and contacts for remote alarm. Provide LED display with current temperature display and highest temp hold and reset functions.

2.11 SECONDARY DISTRIBUTION SECTION TERMINAL COMPARTMENT

A. Low-Voltage Terminal Compartment: Bus bars mounted on standoff insulators or duct flange for close coupling with busway, depending on application.

2.12 SECONDARY DISTRIBUTION SECTION SWITCHGEAR

A. The secondary distribution section shall be drawout, fused where indicated, low-voltage switchgear, complying with IEEE C37.20.1 and UL 1558. Comply with requirements in Section 262300 “Low Voltage Switchgear”.

1. Section barriers between main and tie circuit-breaker compartments shall be extended to rear of section.

B. Switchgear Structure:

1. Match and align the front and back of the switchgear.
2. Isolate line bus from load bus at each main and tie circuit breaker with bus isolation barriers.
3. Allow the following circuit-breaker functions to be performed when the compartment door is closed:
   a. Operate manual charging system.
   b. Open and close the circuit breaker.
   c. Examine and adjust the trip unit.
   d. Read the breaker nameplate.
4. Locate instrumentation transformers within the breaker cell, and make front accessible and removable.

C. Switchgear Bus:

1. Use bus bars to connect compartments and vertical sections. Cable connections are not permitted.
2. Main Phase Bus: Uniform capacity the entire length of section.
3. Neutral Bus: 100 percent of phase-bus ampacity, except as indicated. Equip bus with pressure-connector terminations for outgoing circuit neutral conductors. Include braces for neutral-bus extensions for busway feeders. 100% may be increased to 200% for non-linear load applications.
4. Vertical Section Bus Size: Comply with IEEE C37.20.1, including allowance for spare circuit breakers and spaces for future circuit breakers.
5. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent minimum conductivity, with copper feeder circuit-breaker line connections.
6. Use copper for connecting circuit-breaker line to copper bus.
7. Contact Surfaces of Buses: Silver plated.

8. Feeder Circuit-Breaker Load Terminals: Silver-plated copper bus extensions equipped with pressure connectors for outgoing circuit conductors.
9. Ground Bus: Hard-drawn copper of 98 percent minimum conductivity, with pressure connector for feeder and branch-circuit ground conductors, minimum size 1/4-by-2 inches.
10. Neutral bus equipped with pressure-connector terminations for outgoing circuit neutral conductors. Neutral-bus extensions for busway feeders are braced.
11. Neutral Disconnect Link: Bolted, uninsulated, 1/4-by-2-inch copper bus, arranged to connect neutral bus to ground bus.

D. Circuit-Breaker Compartment:

1. Drawout Features: Circuit-breaker mounting assembly equipped with a racking mechanism to position circuit breaker and hold it rigidly in "connected," "test," and "disconnected" positions. Include the following features:
   a. Interlocks: Prevent movement of circuit breaker to or from "connected" position when it is closed, and prevent closure of circuit breaker unless it is in "connected," "test," or "disconnected" position.
   b. Circuit-Breaker Positioning: Permit the racking of an open circuit breaker to or from "connected," "test," and "disconnected" positions only when the compartment door is closed unless live parts are covered by a full dead-front shield. Permit the manual withdrawal of an open circuit breaker to a position for removal from the structure. When the compartment door is open, status for connection devices for different positions includes the following:
      1) Test Position: Primary disconnects disengaged, and secondary disconnect devices and ground contact engaged.
      2) Disconnected Position: Primary and secondary devices and ground contact disengaged.

E. Circuit Breakers:

1. Comply with IEEE C37.13 and UL 1066.
2. Ratings: For continuous, interrupting, and short-time current ratings for each circuit breaker; voltage and frequency ratings same as switchgear.
3. Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with the following features:
   a. Normal Closing Speed: Independent of both control and operator.
   b. Stored-Energy Mechanism: Electrically charged.
      1) Operating Handle: One for each circuit breaker capable of manual operation.
      2) Electric Close Button: One for each electrically operated circuit breaker.
   c. Electrically operated where remote operation is required. Provide circuit breaker operating power from within switchgear.

4. Trip Devices: Solid-state, overcurrent trip-device system consisting of one or two current transformers or sensors per phase, a release mechanism, and the following features:
   a. For main circuit breakers, provide electronic trip units with programmable curve shaping, ground fault, power and energy monitoring, harmonic

monitoring and analysis, event capture and communications capability to Port's monitoring and control system.

b. For feeder breakers, provide electronic trip units with manual curve shaping, ground fault and energy monitoring and communications capability to Port's monitoring and control system.
c. Functions: Long-time-delay, short-time-delay, and instantaneous-trip functions, independent of each other in both action and adjustment.
d. Temperature compensation that ensures accuracy and calibration stability from minus 5 to plus 40 deg C.
e. Field-adjustable, time-current characteristics.
f. Current Adjustability: Dial settings and rating plugs on trip units, or sensors on circuit breakers, or a combination of these methods.
g. Three bands, minimum, for long-time- and short-time-delay functions; marked "minimum," "intermediate," and "maximum."
h. Pickup Points:
    1) Five minimum, for long-time- and short-time-trip functions. Equip short-time-trip function for switchable I-squared-t operation.
    2) Five minimum, for instantaneous-trip functions.
i. Ground-fault protection, where required by code or design, shall be capable of at least three short-time-delay settings and three trip-time-delay bands; adjustable current pickup.
    1) Arrange to provide protection for four-wire circuit or system.

5. Trip Indication: Labeled, battery-powered lights or mechanical targets on trip device to indicate type of fault. Trip indicators shall use non-volatile memory.
6. Arc-flash reduction maintenance by-pass switch: Provide maintenance by-pass switch to set breaker to instantaneous trip mode. Provide blue indicator light that blinks when in maintenance mode.
7. Provide current limiters where necessary to achieve sufficient fault handling capacity.
    a. Single phase sensing and protection is required when fuse limiters are used.
8. Auxiliary Contacts:
    a. Contacts and switches required for normal circuit-breaker operation, sufficient for interlocking and remote indication of circuit-breaker position. Provide as indicated on drawings.
    b. Spare auxiliary switches, six, unless other quantity is indicated. Each switch shall consist of two Type A and two Type B reversible contacts wired through secondary disconnect devices to a terminal block in stationary circuit-breaker compartment. Switchgear compatible and wired/equipped to connect existing Port's SCADA system.
9. Padlocking Provisions: For installing 3/8 inch hasp padlocks on each circuit breaker to secure its enclosure and prevent movement of drawout mechanism.

F. Key Interlocks: Arranged to prevent opening or closing interlocked circuit breakers, except in a specified sequence. Include mountings and hardware for future installation of key interlocks.

G. Undervoltage Trip Devices: Instantaneous, with adjustable pickup voltage OR,

H. Undervoltage Trip Devices: Adjustable time-delay and pickup voltage.

I. Shunt-Trip Devices, where indicated on drawings.

J. Circuit-breaker and fuse combinations complying with requirements for circuit breakers and trip devices.

1. Fuses: NEMA FU 1, Class L current limiting, sized to coordinate with and protect associated circuit breaker.
2. Circuit Breakers with Frame Size 1600 A and Smaller: Mount fuses on line side of associated circuit breaker**,** on a common drawout carriage, arranged so fuses are accessible only when circuit breaker is in "disconnected" position.
3. Circuit Breakers with Frame Sizes More than 1600 A: Fuses and circuit breakers shall be installed in separate compartments on separate drawout mountings. Interlock fuse drawout element with associated power circuit breaker to prevent drawing out fuse element unless circuit breaker is in "open" position.
4. Open-Fuse Trip Device: Provide for a positive means of tripping and holding circuit breaker in "open" position when a fuse opens. Indicate open-fuse status at front of circuit breaker.

K. Indicating Lights: To indicate circuit breaker is open or closed, for main and bus tie circuit breakers interlocked either with each other or with external devices.

2.13 MAIN-TIE-MAIN BREAKER CONTROL

A. Normal Operation: The switchgear shall operate with both main breakers closed and the tie breaker open.

B. Loss of One Power Source: The main breaker associated with the failed source shall open, after which the tie breaker shall close. The total load shall be served by the remaining source. Upon restoration of the failed source, the open main breaker shall not close, but shall remain open until the system has been investigated by maintenance personnel. Upon verification by maintenance personnel that conditions are satisfactory, maintenance personnel will initiate a closed transition transfer in which the open main breaker closes and the tie breaker opens approximately 50 milliseconds afterward, with no loss of power to any of the loads.

1. In auto mode, after a transfer has taken place, if the source now feeding the load fails and the other source becomes available, the system will transfer to seek the live source. The tie will remain closed during a source-to-source transfer.

C. Manual Transfer: With the switchgear in normal operation, maintenance personnel may initiate a transfer sequence in which either main breaker is selected for opening and the tie breaker closes, after which the selected main breaker opens approximately 50 milliseconds later, without a loss of power to any loads.

1. If utility fails while system is in manual mode, the corresponding utility main will trip if the other utility is available.
2. Generator operation is strictly manual; no automatic actions will occur.

D. Simultaneous Loss of Both Power Sources: Both main breakers shall remain closed and the tie breaker shall remain open.

E. Simultaneous Restoration of Both Power Sources: Both main breakers shall remain closed and the tie breaker shall remain open.

F. Restoration of One Power Source: As described in B, above.

2.14 SECONDARY DISTRIBUTION SECTION NETWORK PROTECTORS

A. The secondary distribution section shall be composed of drawout, fused, low-voltage network protectors, complying with IEEE 57.12.44 and IEEE C37.20.1. The switch shall comply with UL 1066.

1. Rated for continuous service in an ambient temperature of up to 40 deg C, applied to three-phase, four-wire, solidly grounded wye secondary networks. Comply with IEEE C57.12.44.
2. Dead-front, drawout design with externally mounted fuses, using hand-cranked rail system. Include mechanical interlocks to prevent racking in and racking out when protector is closed.
3. Locate the relay and control panel on a separate drawout module.
4. Protector Operator: Stored-energy mechanism, rated to close on a 65,000 rms symmetrical load.
5. Control Voltage: 125 VDC.
6. Program the relay with factory default values. Provide one hand-held pendant to field adjust these values using relay calibration procedures. Include an anti-pumping program to lock the protector open under abnormal conditions.
7. Include current-limiting fuses on network side of protector for protection against switchboard bus faults.

B. Coordinate and comply with requirements of the low-voltage switchgear supplied by the network.

C. Controls: Microprocessor-based, three-phase network relay, with features and functions as follows:

1. The protector control shall use a positive and negative sequence-based algorithm for current and voltage.
2. Close protector if positive sequence power flows into the network. Adjustable closing range shall be from 0.5 to 3.5 V in phase difference between network and transformer voltages.
3. Trip protector if there is a net, three-phase, reverse power flow through protector. Trip protectors shall be adjustable from 0.05 to 5 percent of continuous-current rating of current transformers within protector.
4. Trip protector if there is a flow of reverse magnetizing current to its associated transformer.
5. Relay parameters and watt or watt-var trip values shall be field adjustable.
6. Protector shall not open under any fault on network side of protector.

7. Include auxiliary contacts and control wiring for use with remote pilot devices that provide remote trip and lockout functions in low-voltage switchgear. Include four reversible standby auxiliary contacts and an equal number of N.O. and N.C. types.

D. Network Communications: Data and digital data-transmission interface shall be compatible with the system specified in Section 262713 – "Electrical Power Metering". Communicate the following network relay parameters:

1. Current in each phase.
2. Phase-to-phase and phase-to-neutral voltages.
3. Three-phase watts, vars, and VA.
4. Frequency.
5. Power factor.
6. Network relay set points.

E. Enclosure:

1. With top-mounted transition to connect to the low-voltage power network.
2. Network Switchgear-Mounted Disconnect Switch: Supply each network-protector circuit with a switchgear-mounted fuse truck, with Class L fuses rated for 200-kA interrupting capacity and key interlocked with each associated protector.

2.15 LOW-VOLTAGE INSTRUMENT SECTION

A. Instrument Transformers: Comply with IEEE C57.13.

1. Protective Relays: Comply with IEEE C37.90, integrated digital type; with test blocks and plugs.
2. Multi-functional microprocessor Three Phase Protective Relay with ANSI 50/51, 50/51G or 50/51N incorporated into a single device.
3. Provide separate ANSI devices 50/51 and 50G (or 51G) for each feeder breaker with local alarm and annunciation.
4. Provide synch check relays (ANSI device 25) for main breakers and tie, and for intertie to other active sources.
5. Provide a lockout relay (ANSI device 86) for every breaker.
6. Provide differential bus protection (minimum of two zones, ANSI device 87).
7. Provide an ANSI device 51/51N for each main breaker.
8. Relays shall have long-time, short-time, instantaneous and ground fault settings. Provide necessary software and licenses to set all relays.
9. Relays shall have remote monitoring and metering communication capability via Ethernet, compatible with EATON PQM and PEM web server communications protocol.
10. Provide in the metal-clad circuit breaker, metal-enclosed interrupter switchgear, the quantity, type and rating of protection relays indicated on the drawings.

11. Potential Transformers: Secondary voltage rating of 120 V and NEMA C 12.11 Accuracy Class of 0.3 with burdens of W, X, and Y.
12. Current Transformers: Burden and Accuracy Class suitable for connected relays, meters, and instruments.

13. Compatible with EATON PQM/PEM series meters. Port F&I review, and approval required.

B. Multifunction Digital-Metering Monitor: Microprocessor-based revenue-grade unit, 0.5% accuracy in compliance with WAC and RCW. Remote monitoring over Ethernet TCP/IP backbone. Suitable for three- or four-wire systems. Comply with requirements in Section 262713 “Electricity Metering” and Section 260913 “Power Monitoring and Control”.

1. EATON PQM series, OR EATON PEM series. Port F&I review, and approval required.

C. Relays: Comply with IEEE C37.90, types and settings as indicated; with test blocks and plugs.

D. Surge Suppression: Factory installed as an integral part of the low-voltage switchgear. Refer to Section 264313 “Surge Protection for Low Voltage Electrical Power Circuits”.

E. Control Power Supply: Control power transformer sized to feed all meters on each distribution section.

F. Control Wiring: Factory installed, complete with bundling, lacing, and protection; and complying with the following:

1. Flexible conductors for No. 8 AWG and smaller, for conductors across hinges and for conductors for interconnections between shipping units.
2. Conductors sized according to NFPA 70 for duty required.

G. Maintenance Tools: Furnish tools and miscellaneous items required for circuit-breaker and switchgear test, inspection, maintenance, and operation.

1. Racking handle to manually move circuit breaker between "connected" and "disconnected" positions.
2. Circuit-Breaker Removal Apparatus: Overhead-circuit-breaker lifting device, track mounted at top front of switchgear and complete with hoist and lifting yokes matching each size of drawout circuit breaker installed.
3. Standby-Fuse Cabinet: Identified and compartmented steel box or cabinet with lockable door.
4. Storage for Manual: Include a rack or holder, near the operating instructions, for a copy of maintenance manual. Locate near standby fuse cabinet.

2.16 IDENTIFICATION DEVICES

A. Compartment Nameplates: Engraved, laminated-plastic or metal nameplate for each compartment, mounted with stainless steel, blunt ended self-tapping screws. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems."

B. Torque Values: Provide self-adhesive machine printed label with connection torque values.

2.17 ACCESSORIES:

A. Provide overhead hoist and cart for servicing low-voltage circuit breakers.

2.18 SOURCE QUALITY CONTROL

A. Factory Tests: Perform design and routine tests according to standards specified for components.

1. Conduct transformer tests according to IEEE C57.12.90.
2. Conduct switchgear and switchboard tests according to NEMA C 37.51.

B. Factory Tests: Perform the following factory-certified tests on each secondary unit substation:

1. Resistance measurements of all windings on the rated voltage connection and on tap extreme connections.
2. Ratios on the rated voltage connection and on tap extreme connections.
3. Polarity and phase relation on the rated voltage connection.
4. No-load loss at rated voltage on the rated voltage connection.
5. Exciting current at rated voltage on the rated voltage connection.
6. Impedance and load loss at rated current on the rated voltage connection and on tap extreme connections.
7. Applied potential.
8. Induced potential.
9. Provide factory certified test report.

PART 3 - INSTALLATION

3.1 EXAMINATION

A. Examine areas and space conditions for compliance with requirements for secondary unit substations and other conditions affecting performance of the unit substation.

B. Examine roughing-in of conduits and grounding systems to verify the following:

1. Wiring entries comply with layout requirements.
2. Entries are within conduit-entry tolerances specified by manufacturer, and no feeders will have to cross section barriers to reach load or line lugs.

C. Examine walls, floors, roofs, and concrete bases for suitable conditions for secondary unit substation installation.

D. Verify that ground connections are in place and that requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 2 ohms at secondary unit substation location.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EQUIPMENT INSTALLATION

A. Comply with applicable portions of NECA 1, NECA 400, NECA 410, NECA 430, and NEMA SG 11.

B. For indoor installations, the room in which the unit substation is housed shall have the following:

1. Fluorescent lights with lense, wireguard and low-temperature ballasts and controlled by wall switch at each entrance. Lighting level minimum 70 footcandles at normal power and 40 footcandles emergency.
2. GFCI duplex receptacles, a minimum of two.
3. Electric unit heater(s), wall or ceiling mounted, with integral thermostat and disconnect and with capacities to maintain switchboard interior temperature of 50 deg F with outside design temperature of 21 deg F.
4. Exhaust fan with capacities to maintain switchboard interior temperature of 85 deg F. with outside design temperature of 104 deg F.
5. Supply fan for filtered air to pressurize aisle to 0.1 inches water compared to outside.
6. Ventilating openings complete with replaceable fiberglass air filters.
7. Thermostat: Single stage; wired to control heat and exhaust fan.

C. Install secondary unit substations on cast-in-place concrete equipment base. Comply with Zone 3 seismic requirements. Concrete shall be rated 3000 psi minimum. Base shall be 3-1/2” high and shall extend minimum 4” beyond equipment on all sides.

1. Concrete bases shall be leveled to no more than 0.25 inches of deviation for every 3 feet in ALL directions.
2. Contractor shall notify F&I and AV Maintenance prior to concrete pour to measure concrete base and assess base’s levelness.
3. Concrete bases shall have smooth finishes. Broom finishes are prohibited.

D. Comply with requirements for vibration isolation and seismic control devices specified in Section 260529 "Hangers and Supports for Electrical Systems" and Section 260548.16 "Seismic Controls for Electrical Systems."

E. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

F. Bring transformer to room temperature or a minimum of 65°F for a period of 24 hours prior to energizing. Temperature as measured at transformer hot spot.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems" and in attached Sheets A8 and A17.

1. Install the number of signs required to be readable from each accessible side, but space the signs a maximum of 25 ft. apart.
2. Coordinate with Port F&I to install arc-flash warning labels.

B. Operating Instructions: Place printed operating instructions for secondary unit substations, including key interlocking, control sequences, elementary single-line diagram, and emergency procedures with the maintenance materials.

3.4 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

1. At Interior Locations: For grounding to grounding electrodes, use bare copper cable not smaller than No. 4/0 AWG. Bond surge arrester and neutrals directly to the transformer enclosure and then to the grounding electrode system with bare copper conductors. Keep leads as short as practicable with no kinks or sharp bends. Make joints in grounding conductors and loops by exothermic weld or compression connector.
2. At Exterior Locations:
   a. For counterpoise, use tinned bare copper cable not smaller than No. 4/0 AWG, buried not less than 30 inches below grade interconnecting the grounding electrodes. Bond surge arrester and neutrals directly to the transformer enclosure and then to the grounding electrode system with bare copper conductors, sized as shown. Keep lead lengths as short as practicable with no kinks or sharp bends.
   b. Fence and equipment connections shall not be smaller than No. 4 AWG. Ground fence at each gate post and corner post and at intervals not exceeding 10 ft. Bond each gate section to the fence post using 1/8 by 1 inch tinned flexible braided copper strap and clamps.
   c. Make joints in grounding conductors and loops by exothermic weld or compression connector.

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Tighten electrical connectors and terminals to manufacturer's published torque tightening values. After torqued, install a spot of red paint such that paint will be disturbed if lugs are disturbed.

3.5 CLEANING

A. After completing equipment installation and before energizing, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish. Vacuum interiors of secondary unit substation sections.

3.6 FIELD QUALITY CONTROL

A. Provide the services of a qualified factory-trained manufacturer's representative to assist in installation and start-up of the substation for a period of at least two working days.

1. The manufacturer's representative shall provide technical direction and assistance to the Contractor in the general assembly of the equipment, connections and adjustments, and testing of the assembly and components contained therein.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

1. Air Interrupter Switchgear: Perform inspections and tests stated in NETA ATS Section 7.5 and the following:
   a. Inspect switchgear, wiring, components, connections, and equipment installation. Perform inspections and tests stated in NETA ATS Section 7.1. Test and adjust components and equipment.
   b. Megger test power and control wiring and VLF medium voltage cables prior to energization. Submit test reports.
   c. Interrupter switches: Perform inspections and tests stated in NETA ATS, Section 7.5.
   d. Circuit Breakers: Perform inspections and tests stated in NETA ATS, Section 7.6.
   e. Protective Relays: Perform inspections and tests stated in NETA ATS, Section 7.9.
   f. Instrument Transformers: Perform inspections and tests stated in NETA ATS, Section 7.10.
   g. Metering and Instrumentation: Perform inspections and tests stated in NETA ATS, Section 7.11.
   h. Ground Fault Systems: Perform inspections and tests stated in NETA ATS, Section 7.14.
   i. Battery Systems: Perform inspections and tests stated in NETA ATS, Section 7.18.
   j. Surge Arrestors and Capacitors: Perform inspections and tests stated in NETA ATS, Section 7.19 and 7.20.

2. Transformer Liquid Filled OR Dry Type: Perform inspections and tests stated in NETA ATS Section 7.2 and the following:
   a. Test according to ANSI test codes C57.12.90 for liquid units and ANSI C57.12.91 for dry type units.
   b. After installing transformers but before primary is energized, verify that grounding system at substation is tested at specified value or less.
   c. Inspect bolted electrical connections for tightness.
   d. After installing transformers and after electrical circuitry has been energized, test for compliance with requirements.

e. Perform visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
f. For dry-type transformers include internal inspection through access panels and doors.
g. Perform insulation resistance tests using a megohmeter, winding to winding and each winding to ground with test voltage.
h. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3. Secondary Distribution Equipment: Perform inspections and tests stated in NETA ATS Section 7.1.
4. Metering: Compatibility with metering system shall be demonstrated to F&I and maintenance staff by connection to a PC.

C. Submit written test reports for all tests performed on all equipment.

D. General Field Testing Requirements:

1. Comply with the provisions of NFPA 70B Ch. "Testing and Test Methods."
2. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.
3. After installing secondary unit substation but before primary is energized, verify that grounding system at the substation is tested at the specified value or less.
4. After installing secondary unit substation and after electrical circuitry has been energized, test for compliance with requirements.
5. Visual and Mechanical Inspection:
   a. Verify equipment nameplate data complies with Contract Documents.
   b. Inspect bolted electrical connections for high resistance using one of the following two methods:
      1) Use a low-resistance ohmmeter to compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
      2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.
6. Remove and replace malfunctioning units and retest.
7. Prepare test and inspection reports. Record as-left set points of all adjustable devices.

E. DC System VRLA Batteries Field Test:

1. Visual and Mechanical Inspection:
   a. Verify that batteries are adequately located.
   b. Verify that battery area ventilation system is operable and capable of maintaining temperature in battery area at 77°F, plus or minus 2°.
   c. Verify existence of suitable eyewash equipment.
   d. Verify equipment nameplate data and capacity meets or exceeds requirements in Contract Documents.

e. Inspect physical and mechanical condition.
f. Verify adequacy of battery support racks, mounting, anchorage, alignment, grounding, and clearances.
g. Verify the units are clean.
h. Inspect spill containment installation.
i. Verify application of an oxide inhibitor on battery terminal connections.
j. Verify all torqued battery terminal connections have been torqued per manufacturer's recommendation.

2. Electrical Tests:
a. Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended levels.
b. Verify charger functions and that alarms comply with system manufacturer's recommendations.
c. Measure negative post temperature. Negative post temperature shall comply with manufacturer's published data or IEEE 1188.
d. Measure charger float and equalizing voltage levels. Charger float and equalizing voltage levels shall be according to the battery manufacturer's published data.
e. Measure each monoblock/cell voltage and total battery voltage with charger energized and in float mode of operation. Monoblock/cell voltages shall be according to manufacturer's published data.
f. Measure intercell connection resistances with a micro-ohmmeter.
g. Rack components must be grounded and meet manufacturer's resistance requirements between all components of the rack system.
h. Perform internal ohmic measurement tests. Cell internal ohmic values (resistance, impedance, or conductance) shall not vary by more than 25 percent between identical cells that are in a fully charged state. Monoblock/cell internal ohmic values (resistance, impedance, or conductance) shall not vary by more than 25 percent between identical monoblocks/cells in a fully charged state.
i. Perform a load test according to manufacturer's published data or IEEE 1188 and IEEE 450, or verify manufacturer's factory test. Replace units that fail to pass the test.
j. Measure the battery system voltage from positive-to-ground and negative-to-ground. Voltage measured from positive-to-ground shall be equal in magnitude to the voltage measured from negative-to-ground.

F. DC System Charger Field Test:

1. Visual and Mechanical Inspection:
a. Inspect for physical and mechanical condition.
b. Inspect anchorage, alignment, and grounding.
c. Verify the unit is clean.
d. Inspect filter and tank capacitors.
e. Verify operation of cooling fans and presence of filters.

2. Electrical Tests:

a. Verify float voltage, equalizing voltage, and high-voltage shutdown settings. Float and equalizing voltage settings shall be according to battery manufacturer's published data.
b. Verify current limit. Current limit shall be within manufacturer's recommended maximum.
c. Verify operation of alarms. Results of alarm operation shall be according to manufacturer's published data and system design.
d. Measure and record input and output voltage and current. Input and output voltage shall be according to manufacturer's published data.
e. Measure and record ac ripple current and voltage imposed on the battery. AC ripple current and voltage imposed on the battery shall be according to manufacturer's published data.
f. Perform full-load testing of charger. Charger shall be capable of manufacturer's specified full load.

G. Modification to settings on existing low voltage draw-out circuit breakers: Provide breaker test for modified breaker. Test shall test the functionality of the breaker including, but not limited to, visual and mechanical inspections, trip units and settings, insulation test and primary injection test.

3.7 FIELD ADJUSTMENTS

A. Voltage Monitoring and Adjusting: Before Beneficial Occupancy, provide the following voltage monitoring:

1. Perform 7 days of 3-phase voltage recording at the outgoing section of each substation.
2. If the test results are unacceptable, adjust transformer taps or rebalance loads.

B. Prepare a written report covering monitoring performed and corrective action taken.

3.8 TRAINING AND OPERATING AND MAINTENANCE MANUALS

A. A factory-authorized service representative shall provide a 2-day training session for maintenance personnel at the jobsite, for all shifts.

1. The training session shall include troubleshooting, servicing and preventative maintenance.
2. Provide Operation and Maintenance Manuals.

B. Manufacturer's Certification of proper installation is required.

3.9 FOLLOW-UP SERVICE

A. Voltage Monitoring and Adjusting: After Substantial Completion, but no later than two weeks prior to Final Acceptance, perform the following voltage monitoring:

1. During a period of normal load cycles as evaluated by Port, perform seven days of three-phase voltage recording at the outgoing section of each secondary unit substation. Use voltmeters with calibration traceable to National Institute of Science and Technology standards and with a chart speed of not less than 1 inch per hour. Voltage unbalance greater than 1 percent between phases, or deviation of any phase voltage from the nominal value by more than plus or minus 5 percent during the test period, is unacceptable.
2. Corrective Action: If test results are unacceptable, perform corrective action, as appropriate to bring to manufacturer's specifications.
3. Retests: Repeat monitoring, after corrective action has been performed, until satisfactory results are obtained.
4. Report:
   a. Prepare a written report covering monitoring performed and corrective action taken.
   b. For each relay and adjustable circuit breaker, tag the device with adjusting technician's initials and the date of the adjustment. Record the settings and file with test records specified in "Field Quality Control" Article.

B. Infrared Inspection: Perform the survey during periods of maximum possible loading. Remove all necessary covers prior to the inspection.

1. After Substantial Completion, but not more than two weeks prior to Final Acceptance, perform infrared inspection of the electrical power connections of the unit substation.
2. Follow-up Infrared Scanning: The Port shall have the option of performing its own infrared inspection.
3. Record of Infrared Inspection: Prepare a certified report that identifies the testing technician and equipment used, and lists the following results:
   a. Description of equipment to be tested.
   b. Discrepancies.
   c. Temperature difference between the area of concern and the reference area.
   d. Probable cause of temperature difference.
   e. Areas inspected. Identify inaccessible and unobservable areas and equipment.
   f. Identify load conditions at time of inspection.
   g. Provide photographs and thermograms of the deficient area.
   h. All of the above shall be provided on Microsoft Office software platform. Provide electronic and hard copies of report.
4. Act on inspection results according to the recommendations of NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Port's operations permit. Retest until deficiencies are corrected.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Port's maintenance personnel to adjust, operate, and maintain systems. Training shall be provided for three shifts of personnel with all needed training material. Minimum ten persons per shift.

END OF SECTION 261116.11

Except as noted below:
Interior Nameplate Schedule (Sheet A8)
Exterior Nameplate Schedule (Sheet A17)
Transformer Equipment and Insulation Test Report