

**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. This Section includes metal-enclosed non-drawout interrupter, and metal-clad, draw-out circuit-breaker switchgear with the following optional components, features, and accessories:
  - 1. Copper, silver-plated main bus at connection points.
  - 2. Communication modules.
  - 3. Analog instruments.
  - 4. Relays.
  - 5. Surge arresters.
  - 6. Provisions for future devices.
  - 7. Fungus proofing.
  - 8. Control battery system.
  - 9. Mimic bus.
- B. All switchgear shall be labeled with Arc Flash Hazard level, as calculated by engineer of record. Refer to section 260573 – Power System Study.
- C. Meters shall be Eaton PXM series, per requirements in Section 262713 – Electrical Power Metering.

**1.3 DEFINITIONS**

- A. ATS: Acceptance Testing Specifications.

- B. GFCI: Ground-Fault Circuit Interrupter.

#### **1.4 ACTION SUBMITTALS**

- A. Product Data: For each type of switchgear and related equipment, include the following:
1. Rated capacities, operating characteristics, furnished specialties, and accessories for individual interrupter switches and circuit breakers.
  2. Time-current characteristic curves for overcurrent protective devices, including circuit-breaker relay trip devices and fusible devices.
- B. Shop Drawings: For each type of switchgear and related equipment, include the following:
1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show method of field assembly and location and size of each field connection. Include the following:
    - a. Tabulation of installed devices with features and ratings.
    - b. Outline and general arrangement drawing showing dimensions, shipping sections, and weights of each assembled section.
    - c. Drawing of cable termination compartments showing preferred locations for conduits and indicating space available for cable terminations.
    - d. Floor plan drawing showing locations for anchor bolts and leveling channels.
    - e. Current ratings of buses.
    - f. Short-time and short-circuit ratings of switchgear assembly.
    - g. Nameplate legends.
    - h. Mimic-bus diagram.
    - i. Utility company's metering provisions with indication of approval by utility company.
  2. Design Calculations: Signed and sealed by a qualified professional engineer. Calculate requirements for selecting seismic restraints.
  3. Wiring Diagrams: For each type of switchgear and related equipment, include the following:
    - a. Power, signal, and control wiring.
    - b. Three-line diagrams of current and future secondary circuits showing device terminal numbers and internal diagrams.
    - c. Schematic control diagrams.
    - d. Diagrams showing connections of component devices and equipment.
- C. Samples: Representative portion of mimic bus with specified finish. Manufacturer's color charts showing colors available for mimic bus.

#### **1.5 INFORMATIONAL SUBMITTALS**

- A. Coordination Drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around switchgear where piping and ducts are prohibited. Show switchgear layout and relationships between components and

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adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Identify field measurements.

1. Additional Drawing Submittal Requirements:
  - a. Master drawing index
  - b. Front view elevation
  - c. Schematic and single line diagrams
  - d. Nameplate diagram per ANSI requirements
  - e. Nameplate schedule
  - f. Component list
  - g. Conduit entry/exit locations
  - h. Ratings
  - i. Cable terminal sizes
- B. Manufacturer Seismic Qualification Certification: Submit certification that switchgear, accessories, and components will withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems." Include the following:
  1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
    - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
  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.
  4. Submit final seismic certification for Medium Voltage Switchgear after installation to ensure installation meet all seismic requirements.
- C. Qualification Data: For professional engineer and testing agency.
- D. Source quality-control test reports.
- E. Field quality-control test reports.
- F. Operation and Maintenance Data: For switchgear and switchgear components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
  1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
  2. Time-current curves, including selectable ranges for each type of overcurrent protective device.

## **1.6 QUALITY ASSURANCE**

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the

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InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7.
- C. Source Limitations: Obtain each type of switchgear and associated components through one source from a single manufacturer.
- D. Product Options: Drawings indicate size, profiles, and dimensional requirements of switchgear and are based on the specific system indicated. Refer to Section 016000 "Product Requirements."
- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- F. Comply with IEEE C2.

**1.7 DELIVERY, STORAGE, AND HANDLING**

- A. Deliver in sections of lengths that can be moved past obstructions in delivery path as indicated.
- B. 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.
- C. If stored in areas subjected to weather, cover switchgear to provide protection from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside switchgear; install electric heating (250 W per section) to prevent condensation.
- D. Delivery and storage shall be with a minimum disruption to building or systems. Indoor splits to be bolted to skids. Breakers and accessories to be packaged and shipped separately.
- E. Switchgear to be equipped for handling by crane.
- F. Ship with accelerometers: 0.3gs in the x, 0.9gs in the y and z direction.

**1.8 PROJECT CONDITIONS**

- A. Environmental Limitations: Rate equipment for continuous operation at indicated ampere ratings for the following conditions:
  - 1. Ambient temperature not exceeding 122 deg F.

**1.9 COORDINATION**

- A. Coordinate layout and installation of switchgear and components with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required clearances for workspace and equipment access doors and panels.
- B. Coordinate size and location of concrete bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

**1.10 EXTRA MATERIALS**

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Control Fuses: Three of each type and rating used for control and metering transformers and circuits.
  - 2. Power Fuses: Three of each type and rating used for fusible devices.
  - 3. Indicating Lights: Three of each type installed.
  - 4. Touchup Paint: One pint container of paint matching enclosure finish, packaged with protective covering for storage and identified with labels.
- B. Maintenance Tools: Furnish tools and miscellaneous items required for interrupter switchgear test, inspection, maintenance, and operation. Include the following:
  - 1. Fuse-handling tool.
  - 2. Extension rails, lifting device, breaker truck, 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.
  - 4. One stand-by breaker carriage for each type of breaker employed in a line-up

**1.11 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. Metal Clad Circuit Breaker Switchgear
    - a. EATON – no substitutions.
  - 2. Metal Enclosed Interrupter Switchgear
    - a. EATON – no substitutions

### **2.2 GENERAL**

- A. Description: Switchgear shall comply with NFPA 70, ANSI C2, NESC, ANSI/IEEE C37.20.2 "Metal Clad and Station Type Cubicle Switchgear", ANSI/IEEE C37.20.3 "Metal Enclosed Interrupter Switchgear", NEMA and IEEE standards.
- B. System Configuration: Switchgear designed and suitable for operation on a 12.47kV OR 4.16kV, 3 phase, 3 wire, solidly grounded neutral, 60Hz system.
- C. System Voltage: 12.47kV nominal, 15kV maximum OR 4.16kV nominal, 5kV maximum.
- D. Interrupting Rating: AIC rating shall comply with fault current availability at supply side of switchgear, including motor contribution and power system studies analysis performed by project design team.
- E. Working Space: Provide at least 5 feet working space in front of switchgear (switchgear door width is generally at least 36 inches).
  - 1. Metal-Enclosed Switchgear: Back access to switchgear may be accomplished via suitably installed removable insulated panels in switchgear room walls unless cinder block or concrete construction is used.
  - 2. Metal Clad Switchgear: Code required physical space shall be provided – NO EXCEPTIONS.

### **2.3 SWITCHGEAR CONSTRUCTION**

- A. Fully Equipped Future Switchgear Spaces: Spaces shall be furnished fully equipped with bus bars, shutters, CTs and related wiring and breaker controls.
- B. Provisions for Expansion: Switchgear shall have provisions for expansion by having bus stubs at end and a covered plate for extension.

- C. Conduit Access: Provide knockouts for a minimum of (2) 6-inch conduits top and bottom.

## **2.4 METAL-ENCLOSED INTERRUPTER SWITCHGEAR**

- A. Comply with IEEE C37.20.3.
- B. Comply with IEEE C37.20.7. Provide arc-resistant switchgear, Type 1.
- C. Design Level of Available-Source Fault Current: Integrated short-circuit rating consistent with available fault current indicated.
- D. Ratings: Comply with standard ratings designated in IEEE C37.20.3 for maximum-rated voltage specified.
  - 1. Main-Bus Rating: Minimum 1200 A, continuous.
  - 2. Main Bus Momentary (10 cycles) Current Rating: 40,000 asymmetrical rms amperes.
  - 3. Main Bus 2-Second Current Rating: 40,000 symmetrical rms amperes.
- E. Interrupter Switches: Stationary, gang operated and suitable for application at maximum short-circuit rating of integrated switchgear assembly.
  - 1. Rating: 1200-A continuous duty and load break.
  - 2. Duty-Cycle, Fault Closing: 40,000 asymmetrical A
  - 3. Switch Fault-Closing Rating: 40,000 asymmetrical rms amperes.
  - 4. Switch 2-Second Current Rating: 25,000 rms amperes.
  - 5. Switch Action: No external arc and no significant quantities of ionized gas released into the enclosure.
  - 6. Switch Construction: Supported entirely by interior framework of structure, with copper switchblades and stored-energy operating mechanism.
  - 7. Phase Barriers: Full length of switchblades and fuses for each pole; designed for easy removal; allow visual inspection of switch components if barrier is in place.
  - 8. Grounded metal barrier in front of every switch.
  - 9. Protective Shields: Cover live components and terminals.
  - 10. Fuses: De-energized if switch is open.
  - 11. Permanent OPEN\_CLOSED switch position indicators.
  - 12. Provisions for padlocking switch in open or closed position.
- F. Mechanical Interlock: Prevent opening switch compartment door unless switchblades are open, and prevent closing switch if door is open.
- G. Window: High Impact Viewing window to permit viewing switchblade positions if door is closed.
- H. Accessory Set: Provide tools and miscellaneous items required for interrupter switchgear test, inspection, maintenance and operation.

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- I. Power Fuses: Comply with the following and with applicable requirements in NEMA SG 2:
  - 1. Indicator: Integral with each fuse to indicate when it has blown.
  - 2. Mounting: Positively held in position with provision for easy removal and replacement from front without special tools.
  - 3. Each fusible bay to include 3 fuses in use and 3 spare fuses in storage clips.
  - 4. Current-Limiting Fuses: Full-range, fast-replaceable, current-limiting type that will operate without explosive noise or expulsion of gas, vapor, or foreign matter from tube, OR
  - 5. Expulsion Fuses: Furnished in disconnect-type mountings and renewable with replacement fuse units. Gases emitted on interruption are controlled and silenced by chambers designed for that purpose.
  - 6. Provide interrupting ratings at rated system voltage as required.
- J. Special Configurations: Provide one of the following configurations:
  - 1. 15kV or 5kV two-position non-load break selector switches for selection of two incoming sources where required.
  - 2. A duplex switchgear configuration consisting of two load interrupter switches with common load side bus to feed one load circuit, which shall be fused or unfused as required.
  - 3. An automatic transfer control relay system for two main load interrupter switches with common load bus.
    - a. Switchgear assembly to consist of a dead-front metal enclosed assembly including two load interrupter switches with motor operators and automatic transfer control relay system and auxiliary equipment.
    - b. Transfer system shall be capable of automatically transferring the load bus circuit to the alternate power source upon failure of the preferred source and have capability of operating from remote signal from Port power monitoring and control system.

**2.5 METAL-CLAD, DRAWOUT CIRCUIT-BREAKER SWITCHGEAR**

- A. Vacuum switchgear designed and suitable for operation on a 12.47kV OR 4.16kV 3-phase, 3 wire, reactance grounded neutral, 60Hz system. Switchgear main buses "A" and "B" shall be minimum 2000 amperes with 2000 ampere frame main breakers (N.C.) and tie breaker (N.O.). Main breakers shall not be located at the end of each bus. Fault duties as noted below.
- B. Comply with IEEE C37.20.2.
- C. Comply with IEEE C37.20.7. Provide arc-resistant switchgear, Type 1.
- D. Nominal Interrupting-Capacity Class: 250, 350, 500, 750, 1000 MVA.
  - 1. Ratings: Comply with IEEE C37.04. Main-Bus Rating: Minimum 2000A, continuous.



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- E. Circuit Breakers: Three-pole, single-throw, electrically operated, drawout-mounting units using three individual, vacuum-sealed interrupter modules and including the following features:
1. Maximum Voltage: 15kV OR 5kV
  2. BIL Rated 95kV OR 60kV
  3. 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.
  4. Contact-Wear Indicator: Readily accessible to field maintenance personnel.
  5. Minimum of six spare auxiliary contacts.
  6. Interchangeability: Circuit breakers are interchangeable with vacuum circuit breakers of same current and interrupting ratings.
  7. Provide at least two spare breakers and two equipped spaces for each bus.
  8. Provide one 3200 ampere and one 1200 ampere frame breaker carriage.
  9. Current Rating of Main Circuit Breaker: 3200 A.
  10. Continuous Current Rating of Tie Circuit Breaker: 3200 A.
  11. Continuous Current Rating of Feeder Circuit Breaker: 1200 A.
  12. Short Circuit Current at Rated Maximum kV: 18, 28, 37 kA RMS.,
  13. Closing and Latching Capability: 62, 97, 130 kA Crest.
  14. Three Second Rating: 23, 36, 48 kA.
  15. Operating Mechanism: Electrically charged, mechanically and electrically trip-free, stored-energy operated.
    - 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.
      - 1) Control Power: 48V OR 125V OR 250V DC for closing and tripping
      - 2) 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.
      - 3) 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.
- F. Customer Metering:
1. Provide selective 3-phase voltage, current kVA, kVAR and kWh metering for each breaker. Comply with requirements in Section 260913 Electrical Power Monitoring and Control.
  2. Provide totalized parameter values for bus "A" and bus "B" combined.
  3. All metering shall have provisions for remote monitoring via Ethernet.
- G. Bus Transfer Controls:
1. Provide two out of three bus transfer controls wherein the two mains are momentarily paralleled for source transfer (make-before-break), and thereafter the designated main is tripped and held open.

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2. Provide automatic bus transfer after loss of one source. The affected main breaker shall be tripped and held open.
  3. Include provisions to prevent automatic closure of the tie breaker to a faulted bus.
- H. Accessories:
1. Relay and meter test plug, tools and miscellaneous items required for circuit breaker and switchgear test, inspection, maintenance and operation.
  2. Switchgear main breakers shall have line side and bus side PTs (Star-Star connection is not acceptable).
  3. Provide dry type CPTs at the line side of each source supply to switchgear. Secondary of CPTs shall be 240/120V, single phase. Minimum rating of each CPT shall be 10kVA.
  4. Provide properly rated 120/240V rated automatic transfer switch to feed station battery charger and station lighting load during loss of power.
  5. Thermometers.
  6. Set of 12-point socket wrenches.
  7. Wall-mounted, nonmetallic storage rack.
  8. Set of cell numerals.
- I. Low-DC-Voltage Alarm: Switchgear shall have a monitor for dc control power voltage with an 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.
- J. Grounding and Testing Device: Suitable for phase out, testing, and grounding switchgear bus or feeder if device is installed in place of circuit breaker. Include the following:
1. Portable Grounding and Testing Device: Interchangeable with drawout-mounting, medium-voltage circuit breakers to provide interlocked electrical access to either bus or feeder; electrically operated.
  2. Portable Remote-Control Station: For grounding and testing device.
  3. Control-Cabinet Coupler Cable: Of adequate length to connect device inserted in any switchgear cubicle and control cabinet.
  4. Remote-Control Coupler Cable: 50 feet long to connect control cabinet and portable remote-control station.
  5. Permanent Control Power Wiring: From control cabinet to power source.
  6. Protective Cover: Fabricated of heavy duty plastic and fitted to device.
- K. Circuit-Breaker Test Cabinet: Separately mounted and containing push buttons for circuit-breaker closing and tripping, control relay, fuses, and secondary coupler with cable approximately 108 inches long. Include a set of secondary devices for operating circuit breaker if removed from switchgear and moved near test cabinet. Include provision for storage of test and maintenance accessories in cabinet.
- L. Infrared Windows: Provide windows on the front and back of the Main(s) compartment section. Windows shall provide clear visual of termination points and bus bars.

**2.6 FABRICATION**

- A. Indoor Enclosure: Steel.
- B. Outdoor Enclosure: Stainlesssteel, weatherproof construction; integral structural-steel base frame with factory-applied asphaltic undercoating.
  - 1. Each compartment shall have the following features:
    - a. Structural design and anchorage adequate to resist loads imposed by 125-mph wind.
    - b. Space heater with individual thermostat, minimum of 250W to prevent condensation. Rated at 240V but operated at 120V. Provide two or more sources of 120VAC for space heaters.
    - c. Louvers equipped with insect and rodent screen and filter, and arranged to permit air circulation while excluding rodents and exterior dust.
  - 2. Weatherproof Housing without Aisle (Metal Enclosed Load Interrupter Switchgear Only) shall have the following features:
    - a. Hinged front door with padlocking provisions.
    - b. Interior light with switch.
    - c. Weatherproof GFCI duplex receptacle.
    - d. Power for heaters, lights, and receptacles to be provided by control power transformer.
  - 3. Weatherproof Internal Aisle Construction (Metal Clad Circuit Breaker Switchgear Only) shall have the following features:
    - a. Common internal aisle of sufficient width to permit protective-device withdrawal, disassembly, and servicing in aisle.
    - b. Aisle access doors at each end with exterior padlocking provisions and interior panic hardware to permit exit from the inside. Provide mechanism to defeat external padlocks.
    - c. Aisle space heaters operating at one-half or less of rated voltage, thermostatically controlled.
    - d. Interior vaporproof fluorescent aisle lights with low-temperature ballasts, controlled by wall switch at each entrance.
    - e. GFCI duplex receptacles, a minimum of two, located in aisle.
    - f. Aisle ventilation louvers equipped with insect and rodent screen and filter, and arranged to permit air circulation while excluding rodents and exterior dust.
    - g. Telephone outlet with 2 tele/data jacks.
- C. Finish:
  - 1. Indoor Manufacturer's standard ANSI 61 gray finish over rust-inhibiting primer on phosphatizing-treated metal surfaces.
  - 2. Outdoor: 3.0 mil thick exterior finish spray coat of high-gloss gray enamel
- D. Bus Transition Unit: Arranged to suit bus and adjacent units.
- E. Incoming-Line Unit: Arranged to suit incoming line.
- F. Outgoing Feeder Units: Arranged to suit distribution feeders.

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- G. Utility Metering Section: Constructed to Puget Sound Energy OR Seattle City Light and EUSERC requirements at service points only. Where feasible, request utility company to install revenue metering on utility side of the supply.
- H. Provide overhead hoist and cart for servicing switchgear.
- I. Low Voltage Wiring: Labeled at each terminal point.
- J. Auxiliary Compartments: Arranged to suit house meters, relays, controls, and auxiliary equipment; isolated from medium-voltage components.
- K. Key Interlocks: Arranged to affect interlocking schemes indicated.

## **2.7 COMPONENTS**

- A. Main Bus: Copper, silver plated at connection points, full length of switchgear. NO ALUMINUM BUS OR TERMINATIONS WILL BE ALLOWED.
- B. Ground Bus: Copper, silver plated or copper, minimum size 1/4 by 2 inches; full length of switchgear.
- C. Bus Insulation: Covered with flame-retardant insulation.
- D. Instrument Transformers: Comply with IEEE C57.13.
  - 1. Potential Transformers: Secondary voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.
  - 2. Current Transformers: Multi-ratio, burden and accuracy class suitable for connected relays, meters, and instruments. Provide 0.5: minimum accuracy class as required for metal clad switchgear. CTs shall be compatible with EATON PXM meters.
- E. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems, listed and labeled by an NRTL, complying with Section 262713 Electrical Power Metering, and with the following features:
  - 1. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.
  - 2. Switch-selectable digital display with the following features:
    - a. Phase Currents, Each Phase: Plus or minus 1 percent.
    - b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
    - c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
    - d. Three-Phase Real Power: Plus or minus 2 percent.
    - e. Three-Phase Reactive Power: Plus or minus 2 percent.
    - f. Power Factor: Plus or minus 2 percent.
    - g. Frequency: Plus or minus 0.5 percent.
    - h. Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
    - i. Accumulated energy, in megawatt hours, plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

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3. Mounting: Display and control unit that is flush or semi-flush mounted in instrument compartment door.
  4. Where a main circuit breaker is furnished provide line-side voltmeters.
  5. Manufacturer: EATON PXM 6000/8000 OR 3000 series.
  6. Provide selective 3-phase voltage, current, kVA, kVAR and kWh metering for each breaker.
  7. Provide totalized parameter values for bus "A" and bus "B" combined.
  8. All metering shall have provisions for remote monitoring and control via existing EATON Power-Net monitoring system and shall be Modbus TC/ICP and Ethernet compatible.
  9. Provide CTs for each meter.
  10. Provide PTs including primary and secondary fuses with disconnecting means.
- F. Protective Relays: Comply with IEEE C37.90, integrated digital type; with test blocks and plugs.
1. Multi-functional microprocessor Three Phase Protective Relay with ANSI 50/51, 50/51G or 50/51N incorporated into a single device.
  2. Provide separate ANSI devices 50/51 and 50G (or 51G) for each feeder breaker with local alarm and annunciation.
  3. Provide synch check relays (ANSI device 25) for main breakers and tie, and for intertie to other active sources.
  4. Provide a lockout relay (ANSI device 86) for every breaker.
  5. Provide differential bus protection (minimum of two zones, ANSI device 87).
  6. Provide an ANSI device 51/51N for each main breaker.
  7. Relays shall have long-time, short-time, instantaneous and ground fault settings. Provide necessary software and licenses to set all relays.
  8. Relays shall have remote monitoring and metering communication capability via Ethernet, compatible with EATON PXM web server communications protocol.
  9. Provide in the metal-clad circuit breaker, metal-enclosed interrupter switchgear, the quantity, type and rating of protection relays indicated on the drawings.
- G. Surge Arresters: Distribution class or better, metal-oxide-varistor type. Comply with NEMA LA 1.
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..
- H. Control Power Supply: DC battery system.

**2.8 CONTROL 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.

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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 IDENTIFICATION**

### **A. Identification Nameplates:**

1. Conform to Port Standard Nameplate labeling in Section 260553 Identification for Electrical Systems.
2. Engraved nameplates to be mounted on the face of the enclosure for all main and feeder circuits.
3. Nameplates to be laminated plastic, black characters on white background and secured with stainless steel screws.
4. Nameplates to identify source of feed and loads served, and include the applicable warnings.
5. All control components mounted within the assembly to be suitably marked for identification corresponding to manufacturer's wiring diagrams.

### **B. Torque Values: Provide adhesive machine printed label indicating connection torque values.**

### **C. Materials: Refer to Section 260553 "Identification for Electrical Systems." Identify units, devices, controls, and wiring.**

### **D. Mimic Bus: Continuous mimic bus applied to front of switchgear, arranged in single-line diagram format, using symbols and lettered designations consistent with approved final mimic-bus diagram.**

1. Mimic-bus segments coordinated with devices in switchgear sections to which applied, to produce a concise visual presentation of principal switchgear components and connections.
2. Medium: Tape and graphics as approved.
3. Color: Red.

## **2.10 SOURCE QUALITY CONTROL**

### **A. Before shipment of equipment, perform the following tests and prepare test reports:**

1. Production tests on circuit breakers according to ANSI C37.09.
2. Production tests on completed switchgear assembly according to IEEE C37.20.2.

### **B. Assemble switchgear and equipment in manufacturer's plant and perform the following:**

1. Functional tests of all relays, instruments, meters, and control devices by application of secondary three-phase voltage to voltage circuits and injection of current in current transformer secondary circuits.

2. Functional test of all control and trip circuits. Connect test devices into circuits to simulate operation of controlled remote equipment such as circuit-breaker trip coils, close coils, and auxiliary contacts. Test proper operation of relay targets.
- C. Prepare equipment for shipment.
1. Provide suitable crating, blocking, and supports so equipment will withstand expected domestic shipping and handling shocks and vibration.
  2. Weatherproof equipment for shipment. Close connection openings to prevent entrance of foreign material during shipment and storage.

## **2.11 FACTORY FINISHES**

- A. Finish: Manufacturer's standard ANSI 61 gray finish applied to equipment before shipping.

## **PART 3 - INSTALLATION**

### **3.1 EXAMINATION**

- A. Examine elements and surfaces to receive switchgear for compliance with requirements for installation tolerances, required clearances, and other conditions affecting performance.
1. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. FLOORING:
1. Provide two-part epoxy floor sealant on concrete floors in rooms housing switchgear.
  2. Prime coat shall be thinned and applied as recommended by coating manufacturer.
  3. Drying time between coats shall be as recommended by manufacturer.
  4. Approved manufacturers:
    - a. Engard 460 series
    - b. Porter Paints Speedhide series
    - c. Carbolite Carboguard series

### **3.2 SWITCHGEAR INSTALLATION**

- A. Install switchgear and accessory items according to manufacturer's written installation instructions.
- B. Anchor switchgear assembly to 4-inch, channel-iron sill embedded in concrete base and attach by bolting.



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1. Sills: Select to suit switchgear; level and grout flush into concrete base.
  2. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Section 260548.16 "Seismic Controls for Electrical Systems" for seismic-restraint requirements.
  3. Concrete Bases: 3.5 inches high, reinforced, with chamfered edges. Extend base no less than 3 inches in all directions beyond the maximum dimensions of switchgear, unless otherwise indicated or unless required for seismic anchor support. Construct concrete bases according to Section 260529 "Hangers and Supports for Electrical Systems."
    - a. Concrete bases shall be leveled to no more than 0.25 inches of deviation for every 3 feet in ALL directions.
    - b. Contractor shall notify F&I and AV Maintenance prior to concrete pour to measure concrete base and assess base's levelness.
    - c. Concrete bases shall have smooth finishes. Broom finishes are prohibited.
- C. Provide vaults beneath medium voltage switchgear line-ups installed adjacent to PSE or SCL source substations.
- D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchgear units and components.
- E. Spare Conduits:
1. Provide a minimum of one 6-inch conduit per bus section.
- F. Generator Backfeed Application – Where required, switchgear shall be provided with backup generator connection point.
1. Provide a fully-rated circuit breaker matching the bus ampacity of the switchgear. Breaker shall be the same type as the Main breaker(s) on the switchgear.
  2. Provide generator camlock connection cabinet sized for switchgear. Cabinet shall accept male camlock connectors. Provide male to female camlock adapters.
  3. Where space is limited, provide 10 feet cable with Posi-Lok male connector pigtails, and terminate cable to the load side of the breaker. Cables (with pigtails) shall be coiled neatly within the breaker compartment.
  4. If generator connection point is available, Contractor shall coordinate and ensure generator rental(s) are provided with the correct connector plugs. Contractor shall provide connection adapters as required to connect rental equipment to existing generator connection point.

### **3.3 IDENTIFICATION**

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Section 260553 "Identification for Electrical Systems."
- B. Diagram and Instructions:
1. Frame under clear acrylic plastic on front of switchgear.

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- a. Operating Instructions: Printed basic instructions for switchgear, including control and key-interlock sequences and emergency procedures.
    - b. System Power Riser Diagrams: Depict power sources, feeders, distribution components, and major loads.
  2. Storage for Maintenance: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.
- C. Provide Arc Flash Hazard label on panelboard. Label shall include the following information: Date of study, Engineer of Record, Arc Flash Level and Port of Seattle Representative initial.

### **3.4 CONNECTIONS**

- A. Cable connections at switchgear are specified in Section 260513 "Medium-Voltage Cables."
- B. Tighten bus joints, electrical connectors, and terminals according to manufacturer's published torque-tightening values. After torquing of connectors, apply a spot of red paint.
- C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Provide grounding grid for outdoor switchgear and ground switchgear bus ground bus to ground grid.
- E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and Section 260513 "Medium-Voltage Cables."

### **3.5 FIELD QUALITY CONTROL**

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to assist in the installation and startup of the equipment for a period of two working days. Manufacturer's representative shall provide technical direction and assistance to the Contractor in general assembly of the equipment, connections and adjustments, and testing of the assembly and components contained therein. The manufacturer's representative shall perform the following:
  1. 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.
  2. Megger test power and control wiring and VLF medium voltage cables prior to energization. Submit test reports.
  3. Interrupter switches: Perform inspections and tests stated in NETA ATS, Section 7.5.
  4. Circuit Breakers: Perform inspections and tests stated in NETA ATS, Section 7.6.
  5. Protective Relays: Perform inspections and tests stated in NETA ATS, Section 7.9.

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6. Instrument Transformers: Perform inspections and tests stated in NETA ATS, Section 7.10.
7. Metering and Instrumentation: Perform inspections and tests stated in NETA ATS, Section 7.11.
8. Ground Fault Systems: Perform inspections and tests stated in NETA ATS, Section 7.14.
9. Battery Systems: Perform inspections and tests stated in NETA ATS, Section 7.18.
10. Surge Arrestors and Capacitors: Perform inspections and tests stated in NETA ATS, Section 7.19 and 7.20.
11. Report results in writing.

**B. 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

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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.

C. 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.
3. Provide labels indicating torque values for connections.

D. Infrared Scanning: Two weeks after Substantial Completion and prior to Final Acceptance, perform infrared scan of each switchgear. Remove front and rear panels so joints and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: The Port shall have the option of performing its own infrared inspection.
2. Record of Infrared Scanning: Prepare a certified report that identifies switchgear checked and that describes infrared-scanning results. Include notation of deficiencies detected, remedial action taken and observations after remedial action.

### **3.6 ADJUSTING**

- A. Provide a protective relay coordination study by a licensed Electrical Engineer in the State of Washington.

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- B. Protective Relay Settings: Verify settings provided are appropriate for final system configuration and parameters.
- C. The relays to be set in the field by the Contractor in accordance with settings in a coordination study by the Engineer OR a qualified representative of the manufacturer, retained by the Contractor in accordance with settings designated in a coordinated study required in Section 260573 Power System Studies.
- D. Verify that the fuse size and types are appropriate for final system configuration and parameters.

**3.7 CLEANING**

- A. On completion of installation, inspect interior and exterior of switchgear. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair damaged finishes.

**3.8 PROTECTION**

- A. Temporary Heating: Apply temporary heat to switchgear, according to manufacturer's written instructions, throughout periods when switchgear environment is not controlled for temperature and humidity within manufacturer's stipulated service conditions.

**3.9 DEMONSTRATION AND OPERATION AND MAINTENANCE MANUALS**

- A. Engage a factory-authorized service representative to train Port's maintenance personnel to adjust, operate, and maintain switchgear. Provide training at the job site for 2 normal work shifts. Refer to Section 017900 "Demonstration and Training."
  - 1. Training shall include troubleshooting, servicing and preventative maintenance.
- B. The Test Engineer shall gather record drawings and as-furnished information for switchgear (including appurtenances, battery charger, PTs, relays, etc.) and subsequently generate an integrated, unit specific operation and maintenance manual, complete with schematic diagrams of upstream/downstream systems feeding and being fed by this system.
  - 1. Location of devices, PTs, CTs, relays, metering for this switchgear shall be clearly identified and the function of each unit in the overall scheme of things explained.
  - 2. A binder containing a collection of generic switchgear device cutsheets and disjointed O&M guidelines for generic switchgear does not meet this requirement.
- C. Manufacturer's Certification of proper installation is required.

END OF SECTION 261300