This master should be used by designers working on Port of Portland construction projects and by designers working for PDX tenants (“Tenants”). Usage notes highlight a few specific editing choices, however the entire section should be evaluated and edited to fit specific project needs.

SECTION 261100 - SUBSTATIONS

1. GENERAL
	* + 1. DESCRIPTION
				1. This section describes secondary unit substations, including cast coil transformers and low‑voltage metal-enclosed switchgear utilizing drawout power air circuit breakers.
			2. RELATED WORK SPECIFIED ELSEWHERE
				1. Section 260913, Electrical Power Monitoring and Control
			3. REFERENCES
				1. The secondary unit substations shall be designed, assembled, tested, and installed in accordance with the following standards:

ANSI: American National Standards Institute

ANSI 61: Drinking Water System Components - Health Effects

ANSI C37.20.1: Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear

ANSI C37.50: Low-Voltage AC Power Circuit Breakers Used in Enclosures - Test Procedures

ANSI C37.51: For Switchgear – Metal Enclosed Low-Voltage AC Power Circuit Breaker Switchgear Assemblies-Conformance Test Procedures

ANSI C57.12.00: Liquid-Immersed Distribution Power and Regulating Transformers

IBC: International Building Code

IEEE: Institute of Electrical and Electronic Engineers

IEEE 357.124

NEC: National Electrical Code

NEMA: National Electrical Manufacturers Association

NEMA TP 1: Determining Energy Efficiency for Distribution Transformers

NEMA TR 1: Transformers, Regulators, and Reactors

NETA: National Electrical Testing Association

UL: Underwriters Laboratories

UL 1558: Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear

* + - 1. COORDINATION STUDY
				1. The Port will perform a coordination study for the use of the new electrical equipment in the existing electrical distribution system.
			2. SUBMITTALS

Edit time period in A, depending on length of project.

* + - * 1. Submit the following no later than 30 days after the preconstruction meeting:

Master drawing index.

Front view and plan view of the assembly.

Floor plan.

Top view.

Three-line diagram.

Schematic diagram.

Nameplate diagram and schedule.

Component list.

Conduit entry/exit locations.

Conduit space locations within the assembly.

Assembly ratings including:

Short-circuit rating.

Voltage.

Continuous current.

Basic impulse level for equipment over 600 volts.

kVA.

Major component ratings including:

Voltage.

Continuous current.

Interrupting ratings.

Cable terminal sizes.

Connection details between close-coupled assemblies.

Composite front view and plan view of close-coupled assemblies.

Transformer ratings including:

kVA.

Primary and secondary voltage.

Taps.

Primary and secondary continuous current.

Basic impulse level.

Impedance.

Insulation class and temperature rise.

Sound level.

Anchoring and mounting details.

Key interlock scheme drawing and sequence of operation.

Manufacturer’s handling and storage instructions.

Coordination time versus current curves required for the Port to perform a coordination study for the use of the equipment in the existing electrical system.

* + - * 1. Submit the following upon substantial completion of the work:

As-built drawings and information.

Wiring diagrams.

Certified production test reports.

Manufacturer’s field start-up reports (four copies).

Installation information.

Seismic certification and equipment anchorage details.

Final operation and maintenance manuals.

Recommended renewal parts list.

Manufacturer’s certification (four copies).

* + - 1. QUALITY ASSURANCE
				1. Secondary unit substations shall be suitable for and certified to meet all applicable seismic requirements of the IBC for the ground motion accelerations corresponding to the project location.
				2. The major primary and secondary components within the assembly shall be made by the same manufacturer, who shall be ISO 9000, 9001, or 9002 certified.
				3. The manufacturer shall have produced similar electrical equipment for a minimum period of 10 years.
			2. REGULATORY REQUIREMENTS
				1. The switchgear shall be listed and labeled in accordance with UL 1558.
			3. DELIVERY, STORAGE, AND HANDLING
				1. Handle and store equipment in accordance with the manufacturer’s instructions.
1. PRODUCTS
	* + 1. GENERAL
				1. The secondary unit substation shall be complete from the incoming line terminals to the outgoing line terminals, and shall consist of primary equipment, transformer, and secondary equipment. Provide all major components of the substations, including incoming primary equipment section, transformer and low-voltage section including circuit breakers, and metering components.
				2. Connections between the primary air terminal cabinet and transformer shall be bus, and between the transformer and secondary shall be flexible bus braid.

Provide dimensions or delete.

* + - * 1. The dimensions of the unit substation shall not exceed \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
			1. ACCEPTABLE PRIMARY AND SECONDARY EQUIPMENT MANUFACTURERS
				1. General Electric, Square D, Siemens, Eaton Cutler-Hammer, or pre-bid approved equal.
			2. PRIMARY EQUIPMENT
				1. Air Terminal Cabinet: A NEMA 1 section shall consist of a full height air terminal chamber directly connected to the high voltage side of the transformer. It shall be rated 15 kV. The front access shall have a hinged cover door capable of being padlocked.
			3. SECONDARY EQUIPMENT
				1. Switchgear:

Ratings:

Voltage rating shall be as indicated on the drawings. The entire assembly shall be suitable for 600 volts maximum AC service.

The assembly shall be rated to withstand mechanical forces exerted during short‑circuit conditions, when connected directly to a power source having available fault current 65,000 amperes symmetrical at rated voltage as shown on the drawings.

The bus system shall have a minimum ANSI 4-cycle short-circuit withstand rating of 100,000 amperes symmetrical.

Circuit breakers shall have a minimum symmetrical interrupting capacity of 65,000 amperes. To assure a fully selective system, circuit breakers shall have 30‑cycle short-time withstand ratings equal to their symmetrical interrupting ratings, regardless of whether equipped with instantaneous trip protection or not.

All ratings shall be tested to the requirements of ANSI C37.20.1, C37.50, and C37.51, and shall be UL witnessed and approved.

Construction:

The switchgear shall consist of the required number of vertical sections, bolted together to form a rigid assembly. Cover the sides with removable bolt‑on covers. All edges of front covers or hinged front panels shall be formed. Provide ventilators located on the top of the switchgear over the breaker and bus compartments to ensure adequate ventilation within the enclosure. Fabricate the rear covers in two pieces for ease of handling, and mount using captive hardware.

Provide the assembly with adequate lifting means and capability of being moved into installation position and bolted directly to the floor. Provision shall be made for jacking of shipping groups and for removal of skids or insertion of equipment rollers. The base of the assembly shall be suitable for rolling directly on pipes without skids. Equip the base with slots in the bottom side frame members to accommodate the forks of a lift truck. Construct the base frame members so that the forks cannot protrude into the breaker, bus, or cable compartments of the assembly.

Each vertical steel unit, forming part of the switchgear line-up, shall be a self-contained housing having one or more individual breaker or instrument compartments, a centralized bus compartment, and a rear cabling compartment. Each circuit breaker compartment, or cell, shall be segregated from adjacent compartments and sections, including the bus compartment, by means of steel barriers. It shall be equipped with drawout rails and primary and secondary disconnecting contacts. Provide removable hinge pins on the breaker compartment door hinges. Current transformers for feeder instrumentation, where shown on the drawings, shall be located within the appropriate breaker cells.

The stationary part of the primary disconnecting devices for each power circuit breaker shall consist of a set of contacts extending to the rear, through a glass polyester insulating support barrier. Corresponding moving finger contacts suitably spaced shall be furnished on the power circuit breaker studs which engage in only the connected position. The assembly shall provide multiple silver-to-silver full floating high-pressure point contacts with uniform pressure on each finger maintained by springs. Each circuit shall include the necessary three-phase bus connections between the section bus and the breaker line side studs. Equip load studs with insulated copper load extension buses terminating in solderless-type terminals in the rear cable compartment of each structure. Bus extensions shall be tin-plated where outgoing terminals are attached.

The secondary disconnecting devices shall consist of floating fingers mounted on the removable unit and engaging flat contact segments at the rear of the compartment. The secondary disconnecting devices shall be silver-plated and sliding contact engagement shall be maintained in the CONNECTED and TEST positions.

Equip the removable power circuit breaker element with disconnecting contacts, wheels, and interlocks for drawout application. It shall have four positions: CONNECT, TEST, DISCONNECT, and WITHDRAWN, all of which permit closing the compartment door. The breaker drawout element shall contain a worm gear levering “in” and “out” mechanism with removable lever crank. Provide mechanical interlocking so that the breaker is in the tripped position before levering “in” or “out” of the cell. The breaker shall include a provision for padlocking open to prevent manual or electric closing. The padlocking shall also secure the breaker in the connected, test, or disconnected position by preventing levering.

An insulating flash shield shall be mounted above each circuit breaker to prevent flashover from the arc chutes to ground.

Provide a rear compartment steel barrier between the cable compartment and the main bus to protect against inadvertent contact with main or vertical bus bars.

The switchgear shall be a completely factory assembled, low-voltage metal-enclosed switchgear, utilizing power air circuit breakers as specified herein.

Provide a full height and depth metal barrier between adjacent vertical structures in the cable compartment.

Bus:

Bus bars shall be tin-plated copper or aluminum, provided that the termination connection accepts both copper and aluminum. Mount main horizontal bus bars with all three phases arranged in the same vertical plane. Size the bus based on ANSI standard temperature rise criteria of 65ºC over a 40ºC ambient (outside the enclosure).

Provide a full capacity neutral bus and extend the entire length of the switchgear.

Firmly secure a copper ground bus to each vertical section structure and extend the entire length of the switchgear. The ground bus short-time withstand rating shall meet that of the largest circuit breaker within the assembly.

All hardware used on conductors shall be high-tensile strength and zinc plated. Provide all bus joints with Belleville washers, or equal.

Wiring/Terminations:

Provide small wiring, necessary fuse blocks, and terminal blocks within the switchgear, as required. Control components mounted within the assembly shall be suitably marked for identification corresponding to the appropriate designations on the manufacturer’s wiring diagrams.

All terminal blocks and devices located inside of the hinged control door shall be touch-safe or guarded.

All control wire shall be type SIS. Wire bundles shall be secured with nylon ties and anchored to the assembly with pre-punched wire lances or nylon non-adhesive anchors. All current transformer secondary leads shall first be connected to conveniently accessible short circuit terminal blocks before connecting to any other device. Provide four shorting screws with provisions for storage. All groups of control wires leaving the switchgear shall be provided with terminal blocks with suitable numbering strips. Provide wire markers at each end of all control wiring. Provide plug-in terminal blocks for all shipping split wires. Terminal connections to remote devices or sources shall be front accessible via removable trays within each circuit breaker cubicle. Control fuses for each electrically operated circuit breaker shall also be located in these trays.

Provide NEMA 2-hole compression-type lugs for all line and load terminations suitable for copper or aluminum cable rated for 75ºC of the size indicated on the drawings.

A termination system shall be provided such that no additional cable bracing, tying, or lashing is required to maintain the short circuit withstand ratings of the assembly through 200 kA.

Lugs shall be provided in the incoming line section for connection of the main grounding conductor. Provide additional lugs for connection of the other required grounding conductors.

Circuit Breakers:

Protective devices shall be drawout low-voltage power air circuit breakers. Breakers shall be UL listed for application in their intended enclosures for 100 percent of their continuous ampere rating.

Breakers shall have long time, short time, and ground fault adjustable settings.

Breakers shall be instantaneous except for main breakers.

Breakers shall be manually and electrically operable.

Electronically operable breakers shall be able to be closed with an umbilical or remote panel.

Provide circuit breakers with trip units as shown on the drawings.

Provide circuit breaker crane that is readily accessible.

Electronic Trip Units:

Equip each drawout low-voltage power circuit breaker with a solid-state tripping system consisting of three current sensors, microprocessor-based trip device, and flux-transfer shunt trip. Provide current sensors with operation and signal function. The trip unit shall use microprocessor-based technology to provide the basic adjustable time-current protection functions. True RMS sensing circuit protection shall be achieved by analyzing the secondary current signals received from the circuit breaker current sensors and initiating trip signals to the circuit breaker trip actuators when predetermined trip levels and time delay settings are reached.

Interchangeable rating plugs shall establish the maximum continuous trip ratings of each circuit breaker. Rating plugs shall be fixed type as indicated. Interlock rating plugs so they are not interchangeable between frames and so that a breaker cannot be closed and latched with the rating plug removed.

Complete system selective coordination shall be provided by the addition of the following individually adjustable time/current curve shaping solid-state elements:

Long delay pick-up and time.

Short delay pick-up and time, and selective flat or I2t curve shaping.

Adjustable instantaneous pick-up including adjustable ground fault current pick-up and time, and selective flat or I2t curve shaping.

The microprocessor-based trip unit shall have both powered and unpowered thermal memory to provide protection against cumulative overheating should a number of overload conditions occur in quick succession.

For trip units that do not have an instantaneous adjustment, provide a discriminator circuit to prevent the breaker from being closed and latched on to a faulted circuit.

Internal ground fault protection settings shall not exceed 1200 amperes. Provide neutral ground fault sensors for all breakers.

A representation of the time-current curve on the trip unit shall indicate the protection function settings. The unit shall be continuously self-checking and provide LED indication that the internal circuitry is being monitored and is fully operational.

The trip unit shall contain an integral test panel with a test selector switch and a test push-button. The test selector switch shall enable the user to select the values of test current within a range of available settings. The basic protection functions shall not be affected during test operations. The breaker shall be capable of being tested in either the TRIP or NO TRIP test mode. Provide a keyed receptacle for use with an optional auxiliary power module. The auxiliary power module shall allow the breaker trip unit to be tested with a 120-volt external power source.

Provide a four-digit, 3/4-inch high, LED alphanumeric display. The display shall be high output LED for low-level light readability. LCD displays are unacceptable. The display shall indicate the following data:

Cause of trip.

Instantaneous value of maximum phase and ground current.

Level of fault current that initiated the automatic trip operation.

The trip unit shall include a battery backed-up power/relay module which shall supply control power to the readout display. Following an automatic trip operation of the circuit breaker, it shall maintain the cause of trip history and the mode of trip LED indication as long as its internal power supply is available. Provide a trip reset button to turn off the LED indication after an automatic trip. A test push-button shall energize an LED to indicate battery status. Internal relays shall provide contacts for remote indication of trip mode and high load.

The trip unit face shall have a red LED alphanumeric display that is pre-set to turn on when 85 percent of the trip setting is exceeded (a 40-second delay shall be provided to avoid nuisance alarms).

Metering display accuracy of the complete system including current sensors, auxiliary CT’s, and the trip unit shall be ±2 percent of full scale for current values.

The trip unit shall include a potential transformer module (PTM), suitable for operation up to 600V, 50/60 Hz. The primary of the PTM shall be connected internally to the load side of the circuit breaker through a dielectric disconnect plug. The unit shall calculate energy monitoring parameters as follows:

Peak demand (megawatts).

Present demand (megawatts).

Energy consumption (megawatt hours).

The energy-monitoring parameter values (peak demand, present demand, and energy consumption) shall be indicated in the trip unit display panel.

Metering display accuracy of the complete system of full scale shall be ±3 percent for power values, ±4 percent of full scale for energy values.

Equip the trip unit to permit communication via a network to the SMS 3000 system. Provide the trip unit with an address register for identification on the network. All monitored values shall be transmittable over the network to the SMS 3000 system. The trip units shall be capable of initiating open and close commands, delivered over the network from a remote location.

Maintenance Mode:

Provide a maintenance mode option to reduce arc flash hazard.

Provide selective zone interlocking or similar solution for reduction of arc flash hazard.

Maintenance mode shall be field tested prior to acceptance.

Central Display Unit:

Provide a central display unit on each of the unit substation’s main breakers (one per double-ended unit substation) capable of displaying information and data from trip units specified above.

Miscellaneous Devices:

Provide key interlocks as indicated on the drawings. These interlocks shall keep the circuit breakers trip-free when actuated.

Provide fused control power transformers for each load center (two per double-ended unit substation) or as required for proper operation of the equipment. Provide a manual disconnect ahead of the primary fuses. Control power transformers shall have adequate capacity to supply power to the transformer cooling fans.

Provide network connection point outside of the substation for power monitoring.

Customer Metering:

Provide a separate customer metering compartment with front hinged door in each unit substation’s main breaker.

Provide current transformers for each meter. Current transformers shall be wired to shorting-type terminal blocks.

Provide fused potential taps as the potential source for metering as shown on the drawings.

See Section 260913.

Enclosures:

NEMA 1.

Nameplates:

Provide engraved nameplates, mounted on the face of the assembly, for all main and feeder circuits. Nameplates shall be laminated plastic, black characters on white background, and secured with screws. Characters shall be 3/16-inch high, minimum. Nameplates shall give item designation and circuit number as well as frame ampere size and appropriate trip rating.

Provide master nameplate giving switchgear designation, voltage ampere rating, short-circuit rating, manufacturer’s name, general order number, and item number.

Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on manufacturer’s drawings.

Finish:

All exterior and interior steel surfaces of the switchgear shall be properly cleaned and provided with a rust-inhibiting phosphatized coating. Color and finish of the switchgear shall be the manufacturer’s standard.

Accessories:

Provide a rail-mounted traveling-type circuit breaker lifter on top of the switchgear.

* + - * 1. Transformers:

Provide unit substation identification in blank space.

Ratings

The ratings of the unit substations \_\_\_\_\_\_\_\_\_\_\_\_\_\_ transformers shall be as follows:

|  |  |  |
| --- | --- | --- |
| kVA Rating | 2000/2660kVA | OA (self-cooled)/FA (fan-forced, air-cooled) |
| Impedance | 5.75% |  |
| HV | 12.47kV | kV-Delta |
| HV BIL | 95kV | kV |
| HV Taps | Two 2 1/2% above and below | Two 2 1/2% FCAN & FCBN full capacity |
| LV | 277Y/480V | Volts-Wye |
| LV BIL | 30kV | kV |

Meet energy efficiency standards for dry transformers as defined in NEMA TP-1.

Construction:

Transformers shall be fan-forced, air-cooled (FA) units and shall contain all necessary components and wiring, including fans, for automatically increasing the kVA rating by 33 percent. Provide control power from a control power transformer in the secondary equipment. The FA package shall include an electronic temperature monitor and fan control unit with the following features:

Digital readout.

Indicating lights showing GREEN – power on, YELLOW – fan on, RED – high temperature.

Audible high temperature alarm with alarm silence push button.

Maximum temperature memory with read and reset switch.

Auto/manual fan control switch.

System test switch.

Temperature sensing in all three low-voltage coils.

Auxiliary alarm contact and means for remote control and temperature monitoring.

The electrical insulation system shall utilize Class F material in a fully rated 185ºC system. Transformer design temperature rise shall be based on a 30ºC average ambient over a 24-hour period with a maximum of 40ºC. Solid insulation in the transformer shall consist of inorganic materials such as glass fiber, electrical grade epoxy, and Nomex, or equal. All insulating materials shall be rated for continuous 185ºC duty.

For enhanced environmental protection and improved withstandability to thermal shock and short-circuit stresses, the primary and secondary coil assemblies shall be of cast coil design. Each cast coil shall be cast under vacuum to assure complete, void-free epoxy resin impregnation throughout the entire insulation system.

The average temperature rise of the transformer windings shall not exceed 80ºC when the transformer is operated at full nameplate rating. The transformer(s) shall be capable of carrying 100 percent of nameplate kVA rating in a 40ºC maximum, 30ºC average ambient temperature as defined by ANSI C57.12.00.

High- and low-voltage windings may be copper or aluminum.

The transformer shall be supplied in a knockdown case design, for ease in fitting through limited openings, and shall be constructed of 12-gauge, minimum, sheet steel. It shall be equipped with removable panels for access to the core and coils. Front and rear panels shall incorporate ventilating grills.

The transformer shall be designed to meet the sound level standards for dry transformers as defined in NEMA TR1.

Finish:

Each transformer shall be painted utilizing an initial phosphatizing cleaning treatment, followed by the manufacturer’s standard paint process baked on to a total of 3 to 5 mils average thickness. Units shall be painted in accordance with ANSI 61 for indoor service and shall match the primary and secondary equipment.

Accessories:

Transformer shall include:

Provisions for lifting, jacking, and moving on pipe rollers.

Two ground pads.

Terminal compartments:

The transformer unit shall include a high-voltage metal-enclosed T-entry terminal compartment and a busway flange. Connections between the primary device and transformer shall be bus, and connections between the transformer and secondary shall be flexible bus braid. Provide space and provisions for indoor-type stress cones and for connecting a No. 4/0 ground conductor.

* + - 1. FACTORY TESTING
				1. Factory test the primary and secondary equipment provided under this section. Comply with ANSI and NEMA standards.
				2. The switchgear shall be assembled, wired, adjusted, and tested at the factory. After assembly, test the complete switchgear to assure the accuracy of the wiring and the functioning of all equipment. The main bus system shall be given a dielectric test of 2200 volts for one minute between live parts and ground and between opposite polarities.
				3. The wiring and control circuits shall be given a dielectric test of 1500 volts for one minute or 1800 volts for one second between live parts and ground, in accordance with ANSI C37.20.1
				4. A certified test report of all standard production tests shall be available to the Port upon request.
				5. Factory-test all transformers provided under this section. Comply with ANSI and NEMA standards and include.

Resistance measurements of all windings on the rated voltage connection of each unit and at the tap extremes of one unit only of a given rating.

Ratio tests on the rated voltage connection and on all tap connections.

Polarity and phase-relation tests on the rated voltage connections.

No-load loss at rated voltage on the rated voltage connection.

Exciting current at rated voltage on the rated voltage connection.

Impedance and load loss at rated current on the rated voltage connection of each unit and on the tap extremes.

Applied potential test.

Induced potential tests.

Partial discharge test in accordance with IEEE 357.124.

* + - * 1. Tests will not be required when there is a record of a temperature test available on an essentially duplicate unit. When a transformer is supplied with auxiliary cooling equipment to provide more than one rating, temperature tests as listed above shall be made on the lowest kVA self-cooled rating and the highest kVA fan-forced, air-cooled rating.
1. EXECUTION
	* + 1. INSTALLATION
				1. Install equipment in accordance with the manufacturer’s recommendations and the drawings.
				2. Provide all necessary hardware to secure the assembly in place.
				3. Install and check the equipment in accordance with the manufacturer’s recommendations and the drawings. Include, but not be limited to:

Ensuring that the pad location is level to within .125 inches.

Ensuring that bus bars are torqued to the manufacturer’s recommendations.

Assembling shipping sections, removing shipping braces, and connecting shipping split mechanical and electrical connections.

Securing assemblies to foundation or floor channels.

Measuring and recording megger readings phase-to-phase, phase-to-ground, and neutral-to-ground (four-wire system only).

* + - * 1. Inspecting and installing circuit breakers in their proper compartments.
			1. FIELD QUALITY CONTROL
				1. Provide the services of a qualified factory-trained manufacturer’s representative to assist the Contractor in installation and start-up of the equipment specified under this section for a minimum period of 2 1/2 business days. Ensure that the manufacturer’s representative provides technical direction and assistance to the Contractor in general assembly of the equipment, connections and adjustments, and testing of the assembly and components contained herein.
			2. MANUFACTURER’S CERTIFICATION
				1. Submit written certification from a qualified, factory-trained manufacturer’s representative that the equipment has been installed, adjusted, and tested in accordance with the manufacturer’s recommendations.
			3. TRAINING
				1. The Contractor shall provide a 2-day training session for Port personnel.
				2. The training session shall be conducted by a qualified manufacturer’s representative. Instructions on the assembly including primary equipment, transformer, and secondary equipment. Include all circuit breakers, protective devices, microprocessor metering equipment, and other major components.
			4. TESTING
				1. Provide NETA acceptance tests on unit substations. The tests shall be performed by a NETA Full Member Company and shall include the following:

Tests on the ground fault protection system in accordance with the manufacturer’s instructions.

Adjusting breaker settings per recommendation of coordination study and tests on all ground fault settings as required by NEC.

END OF SECTION 261100