SECTION 16342
MEDIUM VOLTAGE METAL-CLAD SWITCHGEAR

PART 1 - GENERAL

1.01 SUMMARY

This Section includes the technical requirements for the design, fabrication, installation, testing, and delivery of NEMA 3R outdoor, walk-in, aisle protected metal-clad switchgear assemblies, including draw-out circuit breaker sections complete with vacuum circuit breakers and NEMA 3R circuit breaker assemblies.

1.02 RELATED SECTIONS

A. Section 03300, Concrete.
B. Section 16060, Grounding and Bonding.
C. Section 16080, Field Electrical Testing Requirements.
D. Section 16095, System Sequence of Operation.
E. Section 16120, Wires and Cables.
F. Section 16142, Shore Power Outlet Enclosures.
G. Section 16195, Electrical Identification
H. Section 16271, Medium Voltage Dry-type Transformers
I. Section 16343, Medium Voltage Load Interrupter Switchgear.

1.03 SYSTEM REQUIREMENTS

Metal-Clad switchgear shall be integrated with Load Interrupter switchgear as defined in Section 16343, Medium Voltage Load Interrupter Switchgear. The distribution sections shall be bus connected to the metal-clad switchgear described here-in and shall have protected aisle walk-in shelter in front of the distribution sections where shown on the Plans.

1.04 REFERENCES

A. California Electrical Code - NFPA 70, National Electrical Code Amended by the State of California
B. Institute of Electrical and Electronic Engineers (IEEE).

2. IEEE 141 - Recommended Practice for Electric Power Distribution for Industrial Plants
4. IEEE C37.04 - Standard Rating Structure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
5. IEEE C37.06 - American National Standard for Switchgear -- AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis -- Preferred Ratings and Related Required Capabilities. (ANSI/IEEE C37.06)
6. IEEE C37.09 - Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis (including Revisions)
7. IEEE C37.11 - Standard Requirements for Electrical Control for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis. (ANSI/IEEE C37.11)
8. IEEE C37.20.2 - Standard for Metal-Clad and Station-Type Cubicle Switchgear
9. IEEE C37.20.4 - Indoor AC Switches (1 kV - 38 kV) for Use in Metal-Enclosed Switchgear
10. IEEE C37.30 - Standard Requirements for High-Voltage Switches
11. IEEE C57.13 - Standard Requirements for Instrument Transformers

C. National Electrical Manufacturers Association (NEMA).

1. NEMA C29.1 - Test Methods for Electrical Power Insulators
2. NEMA C29.10 - Wet Process Porcelain Insulators - Indoor Apparatus Type
3. NEMA SG 4 - Alternating-Current High-Voltage Circuit Breakers

D. State of California.

1. California Building Standards Code (CBC)
2. California Electric Code (CEC)

1.05 SUBMITTALS

The Contractor shall submit the following in accordance with Section 01330, Submittals:

A. Switchgear Product Data, Outline Drawings, Switchgear and Related Equipment Drawings, Wiring Diagrams, and other information listed below (Submit prior to ordering the equipment).

1. Provide product data for switchgear and related equipment, including features, accessories, characteristics, and ratings for individual components, switches, switchgear breakers, AC panels, DC panels, CTs, PTs, CPTs, protective relays, control relays, lockout relays, test switches, programmable logic controllers, human-machine interface, uninterruptable power sources, batteries, terminal blocks, LEDs, alarm horns, global positioning systems, etc.

2. Provide outline drawings that show the following information and details -
   a. Location and dimensions and identification of switchgear cubicles and components of the NEMA 3R switchgear assembly, and conduit entry locations and termination details.
   b. Height of NEMA 3R switchgear assembly.
   c. Weight of fully assembled and operational NEMA 3R switchgear assembly.

3. Provide Switchgear and Related Equipment Shop Drawings. The drawings must include dimensioned plans, elevations, sections, details, required clearances, and noted service space around equipment. Show method of field assembly and location and size of each field connection, including the following:
   b. Tabulation of installed devices with features and ratings.
   c. Outline and general arrangement drawing showing dimensions, shipping sections, and weights of each assembled section.
   d. Drawing of cable termination compartments showing preferred locations for conduits and indicating space available for cable terminations.
   e. Floor plan drawing showing locations for anchor bolts and leveling channels.
   f. Current ratings of buses.
   g. Short-time and short-circuit ratings of switchgear assembly.
   h. Nameplate legends.
i. Location of terminal blocks to be used for field wiring and for connections to the control system.

4. Provide Wiring Diagrams. For switchgear and related equipment, show, at minimum -
   a. Power, signal, and control wiring.
   b. Three-line diagrams of current and voltage secondary circuits showing device terminal numbers and internal diagrams.
   c. Schematic control diagrams.
   d. Point to point wiring diagrams showing connections of component devices and equipment as well as field terminations for related equipment.

5. Provide a layout of Human Machine Interface (HMI) screens as described in Article 2.06 N of this Section.

6. Provide Operation Key Interlock Logic Diagrams.

7. Provide the Manufacturer Seismic Qualification Certification. Submit certification that switchgear, accessories, and components will withstand seismic forces defined in Article 2.03, *Seismic Requirements* including the following -
   a. Indicate whether the "withstand" certification is based on actual test of assembled components or on calculation. 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."
   b. Include dimensioned plans of the equipment unit, identify the center of gravity, and locate and describe mounting and anchorage provisions.
   c. Detailed description of equipment anchorage devices and anchor requirements on which the certification is based and anchorage installation requirements.

B. Switchgear Prior to Factory Acceptance Testing Information (submit at least one week prior to the factory testing date).

1. Provide Programmable Logic Controller (PLC) Input/Output (I/O) Wiring Diagrams and Logic Diagrams

2. Provide the most recent point to point diagram for use during factory acceptance testing.

3. Provide the protective relay configuration files for all protective relays.
C. Switchgear Time of Shipment Test Reports (for each switchgear assembly)

The Contractor shall submit the supplier's certified factory test reports for all specified tests and ANSI required tests at time of shipment. All testing shall comply with the latest NETA acceptance testing procedure. These test reports shall include, but not necessarily be limited to:

1. **Material Test Reports:** ANSI and NEMA prescribed factory tests for each switchgear and related equipment according to Part 2 "Source Quality Control" Article.

2. **Quality-control test reports:** Certified test reports confirming complete ANSI series test results.

D. Switchgear Manuals and Accessories (due at time of shipment, for each switchgear assembly):

Submit the follow prior to or simultaneously with shipment.

1. **Instruction Manuals:** Furnish three complete sets of instruction manuals, including parts lists, for the circuit breakers and all devices and equipment furnished. The manual shall give complete and detailed instructions for erection, installation, and adjustment. Provide one instruction manual located in a pocket attached to the inside of the NEMA 3R switchgear assembly, and two manuals with final documentation.

2. **Operation and Maintenance Manuals and Data:** Provide two hard copies and two DVDs with .pdf copies with each switchgear shipped. Include the following:
   
   a. **Manufacturer's written instructions:** Include instructions for testing and adjusting circuit breakers, overcurrent protective devices, and switchgear components.

   b. **Time-current curves:** Include curves for selectable ranges for each type of overcurrent protective device.

   c. **Setting Files:** Include multi-function protection relay, PLC, and HMI setting files in hard copy printout and recordable CD format.

   d. **Software:** Provide all required programming software (i.e. Multi-function Protection Relay, PLC, HMI, etc.) installation disks with licenses and all necessary drivers.

E. **NETA Switchgear Field Acceptance Test Results (after installation, for each switchgear assembly).**
Perform switchgear and substation NETA field acceptance tests as per Section 16080, Field Electrical Testing Requirements. Submit results of all field tests on signed and certified test report forms within ten working days following completion of each test.

1.06 EXTRA MATERIALS

For each substation, furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

A. Fuses: Furnish three of each type and rating used for each substation. Include spares for transformers, control power circuits, and fusible devices.

B. Maintenance Tools: Furnish tools and miscellaneous items required for switchgear test, inspection, maintenance, and operation. Include the following:
   1. Fuse-handling tool for each different fuse size used.
   2. Racking handle to move circuit breaker manually between connected and disconnected positions.
   3. Motor driven, remote, racking operator shall be provided for racking the breaker in and out of the cubicle.
   4. Secondary test coupler to permit testing of circuit breaker without removal from switchgear.
   5. Circuit breaker test jumper cable.
   6. Circuit breaker lift truck.

1.07 REGULATORY REQUIREMENTS

A. Conform to requirements of NFPA 70.

B. UL Safety Standards: All components shall be listed, labeled or approved where applicable. The entire assembly shall be UL or NRTL labeled as a complete assembly and as required for acceptance by the City of Oakland.

C. In the event of conflict between the codes and standards, Plans, and this Specification, Contractor shall notify and secure a written clarification before proceeding with the Work.

1.08 QUALITY ASSURANCE

Products shall be listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.
1.09 WARRANTY

A. The Manufacturer shall guarantee all materials and workmanship, including the costs for all parts and labor, for a minimum of 24 months from Substantial Completion.

B. The Manufacturer shall guarantee enclosures for coating adhesion and integrity as per ASTM Standards under normal operating conditions for a period of 20 years.

C. See Section 01770, Contract Closeout, for requirements and submittals regarding warranties.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. The following manufacturers are acceptable:
   1. ABB
   2. IEM
   3. Powell
   4. Powercon
   5. Siemens
   6. Eaton Corporation; Cutler-Hammer Products
   7. General Electric Company
   8. Schneider Electric; Square D Products
   9. Or approved equal.

B. Substitutions: See Section 01620, Product Options and Substitutions.

2.02 PERFORMANCE CRITERIA

Ratings: Switchgear shall have the following ratings:

A. kV, nominal: As shown on the Plans.
B. kV, maximum: 15kV.
C. kV, BIL: 95kV.
D. Power frequency: 60 Hertz
E. Power frequency withstand: 36kV, 1 minute test
F. Main bus continuous, amperes: As shown on the Plans.
G. Short-circuit ratings:
   1. Amperes, RMS symmetrical maximum: 23kA.
2. MVA three-phase symmetrical at rated nominal voltage: 500.
3. Duty-cycle fault-closing amperes, RMS asymmetrical: 37kA.
4. Momentary Current Ratings: Equal to the circuit breaker close and latch rating.
5. System Grounding: Low resistance

2.03 SEISMIC REQUIREMENTS

The Manufacturer shall provide equipment and anchor bolt design with certification to meet IBC-2006 and IEEE-693-2005, per Earthquake Design Criteria for project site as listed below. Manufacturer shall provide seismic calculations prepared by California Registered Professional Engineer to establish anchor bolt requirements.

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2.04 OUTDOOR WALK-IN ENCLOSURE

A. Enclosure shall be of outdoor walk-in protected aisle construction - Enclosure and switchgear shall be completely factory-built, assembled, wired, and tested. All equipment and components shall be new and suitable for continuous operation in a marine environment.

B. Enclosure shall be designed with a sloped, drip-proof roof. Cubicles are to be designed to allow front and rear access and shall not require the routing of line side or load side connections in front of the switch compartment.

C. Switchgear with outdoor construction shall have full-height, gasketed, padlockable exterior doors on the back of the weatherproofed equipment.

D. Enclosure shall be weatherproofed by gaskets and by sealing the end covers, rear covers and other locations to prevent entrance of moisture. The enclosure shall have weatherproof doors.

E. A three-inch steel box frame shall be provided under each vertical section and the equipment sealed, painted and undercoated for outdoor service.

F. All structural drawings shall bear the seal of a Structural Professional Engineer currently licensed in the State of California.
G. The enclosure shall be designed and constructed to withstand external loading conditions as prescribed by the International Building Code for the specified final location.

H. Building components of the enclosures shall be designed to withstand external loading as prescribed by the applicable codes above (as a minimum), or International Building Code for the specified final location with co-lateral considerations as follows:

1. Base system shall be designed to withstand all dead and live loads as applicable, while supported at lift points only.

2. Maximum deflection of all base members shall not exceed L/240 at time of lift, and following final installation, with all applicable dead and live loads applied.

3. Roof loading- Per International Building Code (20 lbs/square foot, minimum)

4. Wind loading- Per International Building Code - Exposure C minimum

5. Seismic- Per PART 2, Design Requirements.

6. All lifting lugs shall be removable.

7. A permanent "DANGER HIGH VOLTAGE KEEP OUT" sign shall be attached to each exterior door.

8. Area classification- General purpose/Non-hazardous.

9. The entire assembly shall be UL or NRTL labeled as a complete assembly.

I. Materials and Construction:

1. All facets of construction through coating and weatherproofing shall be performed indoors, protected from outdoor weather conditions. Construction of the equipment out-of-doors is not acceptable.

2. All permanent components shall consist of materials that do not freely support combustion. Use of wood or any other materials that freely support combustion shall not be allowed as permanent components.

J. Switchgear Low Voltage Circuits

1. All low voltage electrical circuit components shall be UL listed and recognized devices.

2. All low voltage circuits shall be functionally tested by the manufacturer prior to completion. Manufacturer shall provide certification that all systems have satisfactorily completed functional testing.
3. Interior ceiling lights shall be provided for interior illumination. Provide two-lamp fluorescent fixtures with cold weather ballasts.

4. Light switch specification grade 20A 125V. Three-way light switch shall be at each entrance door.

5. Duplex receptacles are to be specification grade 20A 125V ivory GFCI duplex type, one at each end of walk-in enclosure.

6. Provide interior exit/emergency lights above entry doors.

7. Provide exterior LED lights above entry doors with photo cell and weatherproof hand-off-auto control.

8. Provide exhaust fans, thermostat controlled.

9. Provide exterior minimum 110 dB horn triggered by PLC alarms, as acceptable to the Port.

10. Wire type - "THHN/THWN"
    a. Power wiring #12 AWG minimum (sized as required by CEC by manufacturer).
    b. Switchgear internal wiring shall be type SIS.

11. AC 120/240V panel, 1 phase, circuit breakers, surface mount, 10,000 AIC for space heaters, lights, receptacles, etc.

12. DC 125VDC panel, circuit breakers, surface mount, 10,000 AIC for 125VDC protective devices, control, etc.

13. Wiring circuits-Provided by Manufacturer:
    a. AC wiring to interior lighting
    b. AC wiring to receptacles
    c. AC wiring to switchgear enclosure space heaters
    d. DC wiring to circuit breaker charging circuits
    e. DC wiring to circuit breaker control and protective device circuits
    f. DC wiring to circuit breaker tripping circuits
    g. Other AC and DC wiring as required

14. Conduit Exposed 3/4" EMT minimum

15. Ground lugs bolted to stainless steel pads at base

16. Fiber optic Ethernet network communication cables to all necessary devices.

2.05 OUTDOOR NON-WALK-IN ENCLOSURE

A. Enclosure shall be of outdoor non-walk-in construction. Enclosure and switchgear shall be completely factory-built, assembled, wired, and tested. All equipment and components shall be new and suitable for continuous operation in a marine environment.

B. Cubicles are to be designed to allow front and rear access and shall not require the routing of line side or load side connections in front of the switch compartment.

C. Switchgear with outdoor construction shall have full-height, gasketed, pad-lockable doors with 3-point latches.

D. The enclosure shall be weatherproofed by gaskets and sealing the end covers, rear and front covers and other locations to prevent entrance of moisture.

E. All structural drawings shall bear the seal of a Structural Professional Engineer currently licensed in the State of California.

F. The entire assembly shall be UL or NRTL labeled as a complete assembly.

G. Materials and Construction:

1. All facets of construction through coating and weatherproofing shall be performed indoors, protected from outdoor weather conditions. Construction of the equipment out-of-doors is not acceptable.

2. All permanent components shall consist of materials that do not freely support combustion. Use of wood or any other materials that freely support combustion shall not be allowed as permanent components.

H. Switchgear Low Voltage Circuits

1. All low voltage electrical circuit components shall be UL listed and recognized devices.

2. All low voltage circuits shall be functionally tested by the manufacturer prior to completion. Manufacturer shall provide certification that all systems have satisfactorily completed functional testing.

3. Interior vestibule LED lights shall be provided for interior illumination.

4. Light switch specification grade 20A 125V.

5. Duplex receptacles are to be specification grade 20A 125V ivory GFCI duplex type, one at each breaker enclosure.
6. Wire type- "THHN/THWN"
   a. Power wiring #12 AWG minimum (sized as required by CEC by manufacturer).
   b. Switchgear internal wiring shall be type SIS.
7. AC 120/240V panel, 1 phase, circuit breakers, surface mount, 10,000 AIC for space heaters, lights, receptacles and etc.
8. Wiring circuits-Provided by Manufacturer:
   a. AC wiring to interior lighting.
   b. AC wiring to receptacles.
   c. AC wiring to switchgear enclosure space heaters.
   d. DC wiring from 6.6kV walk-in enclosure to circuit breaker charging circuits.
   e. DC wiring from 6.6kV walk-in enclosure to circuit breaker control and protective device circuits.
   f. DC wiring from 6.6kV walk-in enclosure to circuit breaker tripping circuits.

2.06 MATERIALS AND EQUIPMENT- SWITCHGEAR

A. Switchgear units shall be arranged as shown on project Plans.

B. The switchgear assembly shall be metal-clad construction with power bus, draw-out circuit breaker sections, cable termination and auxiliary compartments. Surge arresters, instrument transformers, relays, control wiring, accessory devices and connections shall be provided as described herein and as shown on the Plans.

C. Construction stationary structure:

1. In establishing requirements for the enclosure design, consideration shall be given to all relevant factors such as controlled access; tamper resistance; corrosion resistance; protection from ingress of rodents, insects, and weeds; and the possibility of arcing faults within the enclosure.
   a. The switchgear line-up shall be comprised of the required number of metal-clad sections, bus-connected and integrated to the metal-enclosed switches, assembled together to form a rigid self-supporting structure with barriers of painted steel between units.
   b. Each metal-clad section shall consist of the required number of substructures; segregated by grounded metal barriers into separate compartments for incoming connections, outgoing connections, circuit breakers, instrument transformers, main bus, instruments and relays.
c. Switchgear manufacturer shall minimize the footprint of the proposed switchgear lineup by stacking PT/CPT and circuit breakers into one section.

d. The enclosure dimensions shown on the drawings reflect anticipated equipment dimensions. Should actual equipment dimensions differ from those shown, the contractor shall make appropriate changes to the enclosure dimensions and, if necessary to the overall substation dimensions, including but not limited to equipment foundation pad, after consultation with the Engineer.

2. Doors and panels:

a. Each circuit breaker, auxiliary section and voltage transformer compartment shall be provided with a formed, hinged, front door with handle, 3-point latch and provisions for padlocking. Each door shall be furnished with a stop to hold the door in the open position. Circuit breaker and instrument transformer compartment doors shall not hinder withdrawal of the element from the compartment when the door is open and door-stop set.

b. Switchgear mimic bus diagram shall be permanently affixed to the front of the switchgear as per Section 16195, Electrical Identification.

c. No energized parts are to be within normal reach of the opened doorway. Energized bare parts, including, but not limited to, protective relays, lockout relays, test switches and LEDs, mounted on doors shall be guarded where the door must be opened for maintenance of equipment.

d. Relays, instruments, meters, and secondary control devices shall be mounted on formed front-hinged doors provided with handle lockable latch, and stop to hold panel in the open position. Equipment mounted on the door shall be isolated by grounded metal barriers from all primary circuit elements.

e. Access to main bus, incoming service connections, feeder cable terminations, current transformers, bushings, and other stationary devices shall be provided with gasketed, hinged, bolted doors. Filters shall be provided at ventilation louvers. All rear doors shall have hasps or vault handles and provision for padlocks and 3-point latching system.

3. Circuit breaker compartments:

a. Circuit breaker compartment shall be designed to house a drawout type circuit breaker element. Welded horizontal guide rails shall be provided for rolling circuit breakers into designated positions.
b. The circuit breaker compartment shall be closed-door-draw-out design, to allow the breaker to be racked between positions with the front door closed for safety. Breaker position indicator shall be viewable from the front with the compartment door closed and latched.

c. A manually operated jackscrew racking mechanism shall be provided in each breaker compartment to move the breaker between the Connected and Test/Disconnected positions.

d. A motor driven, remote, racking operator shall be provided for racking the breaker in and out of the cubicle. Motor drive mounting hardware shall be installed for use of the remote drive at each circuit breaker compartment.

e. Provide self-coupling primary and secondary contacts at each circuit breaker compartment.

f. Automatic shutters shall be provided in the compartment to prevent accidental contact with the stationary primary disconnecting contacts when the circuit breaker element is withdrawn from the connected position.

g. A ground bus shall extend into the compartment to automatically ground the circuit breaker frame in the Connected and Test positions. The ground bus shall maintain grounding of the circuit breaker frame during the transition between all positions.

h. Means shall be provided for positively holding the circuit breaker element in place when it is in either the Connected or Test/Disconnected position within the compartment. Mechanical interlocks shall also prevent incorrect movement of a closed circuit breaker to or from the designated positions within the compartment, and prevent electrical closing of the circuit breaker within the compartment unless it is in the Connected or Test position.

i. Provision shall be made for padlocking the circuit breaker element in the Test/Disconnected position with a 1/4 inch diameter x 1 inch shackle padlock. Circuit breaker positions shall be clearly identified.

j. Circuit breaker compartments shall only permit the interchange of circuit breaker removable elements of the same type and rating.

4. Voltage transformer compartment: Draw-out type with roll-out trays designed to house the specified transformer assembly. All connections to roll-out voltage transformer trays shall be rigid bus bars insulated to full voltage rating of switchgear assembly. Compartment door shall be furnished with interlock to prevent access to the transformer and primary fuses unless they are disconnected from the primary circuit. Means shall be provided to prevent accidental access to the stationary primary contacts when the transformer and fuses are not in the connected position.
5. **Main bus:**

   a. The main three-phase bus shall be comprised of tin-plated electrical grade copper. Bus shall be fully insulated over its entire length with flame-retardant, non-hygroscopic, track-resistant insulation. All bus connections, including bus taps and circuit breaker tap connections, shall be tin-plated copper, with current density equal to 1000A per sq. in. (155A/cm²) of cross-section.

   b. The main bus and connections shall be braced to withstand the mechanical stresses associated with rated short-circuit momentary currents without deformation or damage to supports.

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

6. **Ground bus:** A tin-plated copper ground bus, not less than 2 inches x 1/4 inch, shall extend the length of the switchgear sections. In each switchgear unit, where power buses enter or leave the switchgear at the top, a copper ground bus, not less than 1 inch x 1/8 inch, shall be extended from the main ground bus up to the top of the unit. All joints in the ground bus shall be made with a minimum of two bolts. Station ground connection points shall be located in each end section. Ground bus assembly shall be capable of withstanding rated momentary fault current without damage.

7. **Bus transition units:** Provided with the switchgear assembly as required by manufacturer's design of line-up. The transition unit structures shall be full-height with front and rear bolted access panels. Front panel shall be in line with those of the adjacent switchgear sections.

8. **Furnish nameplates for each device as indicated in Plans.** Nameplates shall be black letters on white background. There shall be a master nameplate that indicates equipment ratings, manufacturer's name, shop order number and general information.

D. **Medium-voltage AC circuit breakers:**

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

2. Type: The circuit breakers shall be indoor, three-pole, draw-out type, with sealed vacuum, DC motor-charged spring-operated mechanisms. Opening and closing speed shall be independent of the operator or of control voltage within the rated control voltage range. Circuit breakers of the same rating shall be physically and electrically interchangeable.

3. Ratings: The circuit breakers shall be rated on a symmetrical current basis and have the following ratings and required related capabilities and defined in ANSI C37.04:
a. Nominal operating voltage, RMS: as shown on the Plans.
b. Rated maximum voltage, RMS: 15kV.
c. Insulation Withstand, Crest: 95 kV

d. Rated continuous current at 60 Hz amperes, RMS: as shown on the Plans.
e. Nominal MVA Class: 500
f. Required symmetrical current interrupting capability at nominal operating voltage (12.47 kV), RMS, minimum: 23kA.
g. Required closing and latching capability, RMS, minimum: 37kA.
h. Rated interrupting time, cycles, maximum: 3.
i. Rated permissible tripping delay, seconds: 2.

4. Acceptable manufacturers include:
   a. ABB
   b. Cutler-Hammer
   c. General Electric
   d. Powell
   e. Siemens
   f. Square-D
   g. Or approved equal

5. Insulation structure: Materials used for circuit breaker insulation shall be of a type that is noncombustible, non-hygroscopic and tracking resistant. The mechanical strength and physical characteristics of the insulation structure shall match the stresses imposed by the circuit breaker required closing and latching current capability.

6. Removable assembly:
   a. The circuit breaker removable elements shall be truck-mounted with pull-bar or handles suitable for manual removal and insertion of the element out of and into the stationary compartment.
   b. The removable element shall be provided with a fully interlocked, manually-operated racking mechanism to move the circuit breaker between the Test/Disconnected, and Connected positions. A clearly-visible position indicator shall be provided.
   c. It shall be impossible to insert a circuit breaker of incorrect rating in a circuit breaker compartment.
   d. The removable element frame shall be provided with a full front metal shield to prevent access to any live primary bus or load terminals when the circuit breaker is in the “Connected” position.
e. The circuit breaker removable element's primary disconnecting contacts shall be provided with heavy-duty, self-aligning, spring-loaded, silver-plated, copper disconnect fingers that engage with the line- and load-side stationary disconnecting contacts.

f. The circuit breaker interrupters shall be provided with means for determining contact wear without dismantling.

g. Control wiring connections, from circuit breaker compartment to the removable element, shall have provisions for maintaining or automatically reinstating circuit continuity when the removable element is moved between the Connected and Test positions. Suitable means shall be provided for simultaneous disconnection of control wiring connections when the removable element is fully withdrawn from the compartment.

h. Auxiliary switches: Circuit breaker auxiliary contacts shall be used instead of cell-mounted mechanism operated contacts for each breaker. The auxiliary contacts shall be wired through the automatic secondary disconnect system. A 12-contact (6-"a", 6-"b") truck operated contact actuator and switch assembly shall be provided to indicate when the breaker is in the fully connected position, for each breaker. Provide 25% spare contacts and wired to terminal blocks for easy access and future use.

7. Operating mechanism:

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

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

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

d. Each mechanism shall be provided with four-digit, non-resettable mechanical register type operation counter to record each circuit breaker close/open cycle.
e. The mechanism shall be provided with Open and Close mechanical control pushbuttons, mounted on the removable element escutcheon plate, for test purposes and for use in emergency. The mechanism shall also be furnished with an easily readable mechanical position indicator, mounted on the removable element, to indicate the "Open" and "Closed" positions of the main moving contacts.

8. Circuit breaker control:

The circuit breakers shall be designed for local electrical operation at 125 volts DC nominal control power supply.

9. Control Relays CR-ESD1 CR-PERM1, 2, 3, 4

The control relays shall be heavy duty industrial, din-rail mount, with contacts minimum rating 600VAC, 20amps, Allen-Bradley or approved equal.

10. 6.6kV Circuit Breaker Control Switches:

a. Breaker control Switches shall be located at the Human Machine Interface (HMI), relay and control panel.

b. Breaker control switch at the breaker section is not required, except for the associated LED lights (Green, Red and Blue LEDs).

c. Breaker control switch shall be equipped with a clear plastic cover to prevent inadvertent operation.

11. 12.47kV Breaker control switches and associated LED lights (Green, Red and Blue LEDs) shall be located at the breaker section.

12. Cell Switches:

a. Both truck-operated cell switch and mechanism-operated cell switch shall be provided, and need to be readily accessible. They shall be mounted at the front of the circuit breaker cell.

b. Provide 25% spare contacts wired to terminal blocks.

13. Circuit Breaker Test Provisions:

a. The switchgear shall have a circuit breaker test cabinet installed on the interior of the protected aisle structure for operating a circuit breaker removed from the switchgear.

b. Provide an eight foot umbilical cord circuit breaker test cable for operating a circuit breaker removed from the switchgear.
E. Control Power Transformer: Control Power transformer shall be as shown on the Plans.

Acceptable manufacturers include:

1. ABB
2. Cutler-Hammer
3. ITI
4. Siemens
5. Square-D
6. Or approved equal

F. Surge arresters:

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

2. Ratings: Arrester rating, kV, RMS, shall be three-phase, 60 Hz suitable for use at 12.47kV solidly grounded and 6.6kV resistance grounded nominal service voltages. MCOV (Maximum Continuous Operating Voltage (MCOV) rating shall be as shown on the Plans.

3. Arrangement:
   a. Arrester pressure relief diaphragm shall be arranged in the enclosure so that the vent ports are directed away from all adjacent apparatus.
   b. Arrester ground terminals shall be directly connected to the switchgear main ground bus.

G. Current Transformers: CT ratings shall be in accordance with ANSI/IEEE, C57.13 and C37.20.2 and shall have an accuracy class of C200 for window type and T200 for bar type, minimum. The CT winding shall terminate in a screw type terminal on the CT housing and shall be wired to shorting terminal blocks. CTs for metering purposes shall be bar type, and for all other purposes shall be window type, or a shown on the Plans. CTs shall be multi-ratio, dual ratio, or fixed ratio, and set as indicated on the Plans.

Acceptable manufacturers include:

1. ABB
2. Cutler-Hammer
3. ITI
4. Siemens
Shore Power, Berths 30 and 32
2011-09-M1

5. Square-D
6. Or approved equal

H. Potential Transformers: Potential transformers shall be draw-out type with ratings and accuracy in accordance with ANSI C57.13. PTs shall have fused primary and secondary.

Acceptable manufacturers include:

1. ABB
2. Cutler-Hammer
3. ITI
4. Siemens
5. Square-D
6. Or approved equal

I. Relays and instruments: Switchgear assembly shall have protective relays with status indication and event history. A trip and lock out ANSI Device 86 shall be provided for trip signals to the circuit breaker. Circuit breaker protection and control shall comply with the requirements of the single-line diagram and as identified herein.

1. Required protective functions for 6.6kV breakers shall be as specified in Section 16095, System Sequence of Operation, Articles 1.05 and 1.06.
2. Required protective functions for 12.47kV breakers shall be as indicated on the Plans.
3. Protective relays shall be solid-state microprocessor-based multi-functional type providing monitoring, control, and automation that operate from the secondary of current and voltage transformers. Protective relays shall be true RMS sensing of each phase and ground. Relay self-checking functions shall be included, with a minimum of 100mps Ethernet connectivity via glass fiber optics.
4. Provide relays as indicated on Plans for each circuit breaker. Relays shall have power ride-through modules. All relays shall have panel mounted voltage and current test blocks.
   a. Ground element shall be capable of being utilized in residual, zero sequence, or ground source connection schemes, or deactivated.
   b. Device curves and settings shall be independently field selectable and programmable with or without load.
   c. The relay shall store five of the latest 15-cycle events, and event summaries for the latest 20 events. The latest event shall be stored in nonvolatile memory.
   d. Instantaneous, demand and peak demand currents shall be
displayed on the front panel.

e. The relay shall be capable of withstanding operating temperatures ranging from -40°C to +85°C (-40°F to +185°F).

f. Relay Alarm and/or Trip contacts shall not change state if power is lost or an undervoltage occurs. These contacts shall only cause a trip upon detection of an overcurrent or fault condition based upon programmed settings.

g. The relay shall be suitable for operating on control power with a nominal input voltage of 125 volts DC. The power source will be from 125 VDC battery distribution panel. The relay shall be the dual power source type.

h. Provide LED (Amber) for device 86 coil status.

i. Provide LED (Blue) for device 52 spring charger mechanism.

j. Acceptable PG&E rule 21 Relay manufacturers:
   i. ABB
   ii. Basler
   iii. General Electric
   iv. Schweitzer
   v. Siemens
   vi. Or PG&E approved equal

J. Provide adequate test switches which shall completely isolate all protective devices from power, inputs, outputs, current signals and potential signals.
K. Programmable Logic Controller (PLC)

1. The PLC shall be utility grade, with EMI immunity and must comply with IEC 61000-4.4 Electrical Fast Transient Standard.

2. The PLC shall be microprocessor based, with input and outputs required to meet all switchgear control and HMI functions. The PLC shall be mounted in the switchgear HMI section and provide interlocking logic and control of circuit breaker permissives, circuit breaker closures, lockouts, indicating lights, alarms, space heater operation and other operations. A 125Vdc distribution panel shall power the PLC.

3. The PLC shall indicate all equipment status and perform all automation functions. All programmable logic and data shall remain in the memory upon loss of dc power supply. Upon power up, the PLC shall determine the status of the system and ensure an orderly and safe return to operations.

4. Upon loss of power or other PLC malfunction, the PLC shall fail in a safe manner, including but not limited to tripping the main 6.6 kV circuit breaker and locking it out.

5. The PLC shall be programmed to support the sequence of operation and point list described in Section 16095, System Sequence of Operation. A software based sequence of operation shall be submitted to the Engineer.

6. The PLC logic shall ensure that more than one SPO circuit cannot be energized at the same time, by tripping the main circuit breaker when any attempt is made to close more than one SPO Power Switch. PLC sequence of operation interlock is only to complement the mechanical interlocks. The mechanical interlock shall be the primary means of operation control.

7. All fiber optic cabling connecting the PLC and any other substation components shall be minimum 100mps.

8. Acceptable manufacturers include:
   a. ABB
   b. Allen Bradley
   c. Cutler-Hammer
   d. General Electric
   e. Schweitzer
   f. Siemens
   g. Square-D
   h. Or approved equal
L. Ethernet switches must have IEC 61850-3 EMI immunity, -40 to 85°C operating range. Layer 3 routing and redundant features for substation conditions, ruggedized, modular and rack mount design with maximum flexibility with high glass fiber optic and Gigabit port density. The switches shall meet IEEE 1613 industry standard for error-free device operation for substation environments.

M. IP addresses shall be unique for each substation device and be numbered as follows: 10.10.0.BERTH NUMBER.DEVICE NUMBER (starting with "1"), followed by the corresponding device subnet or gateway.

N. Human Machine Interface (HMI)

1. The HMI shall be microprocessor based ruggedized utility grade 21-inch minimum capacitive touch screen with rack mounted sliding backup keyboard with built-in track ball located on the front panel of the switchgear HMI section. Hardware performance shall include -

   a. Time Sync via GPS synchronization clock signal (for all events and alarms)
   b. Data logging with backup and uploading capabilities
   c. Fault record with waveform captures capabilities
   d. Run Protection Relay Parameters Setting Programs
   e. Provision for future SCADA connectivity

2. HMI screen views shall be as follows:

   a. HMI navigation shall be browser-base interface with home button, backward arrow button, forward arrow button, refresh button, list history of screens visited and etc. for screen navigation
   b. Status of all breakers and disconnect switches shall be displayed along with voltage, current and power values for the transformer and shore power receptacle circuits.
   c. The HMI status screen shall graphically show the 12 kV and 6.6 kV shore power system, Single line and switchgear elevation with real time graphical status (color changes according to energized equipment busbars, transformer, breakers, load interrupter switches, etc.) with the following:

      i. Transformer status from transformer monitoring system: coil temperatures
      ii. NGR current
      iii. Breaker status, position (draw out/rack in), status (charged, opened, closed tripped) voltage, current and all the data from meter
      iv. Medium voltage load interrupter switch status, current on each cable from protection relay
      v. Shore power outlet status, interlock key status
vi. 86 lockout reset help screen to instruct operator the reset process

vii. Ethernet communication status screens

viii. Map view locations of SPO Vaults and Shore Power Substation and its respective upstream Substation

ix. Power management (tabulated format real time data KW, KVAR, KVA, pf, KWH, KVARH, KVA demand and etc.)

x. Alarm on primary blown fuse protections and instruction to de-energized upstream equipment,

xi. HMI Alarm Screens which activate the switchgear exterior alarms and horns

xii. Alarms indicated on the Points List that are annunciated on the screen adjacent to the corresponding single line graphic symbol. Alarm conditions shall flash until reset by touch screen, and reset to normal when the condition has been corrected. Alarms shall include protective device trips which are communicated over the fiber network.

xiii. History of all trip and alarm conditions. History shall be filtered and searchable by and combination of keywords.

xiv. Power (Real, reactive and apparent), delivered to each ship, day, time and duration of connection and disconnection in a tabular format.

3. HMI Control Screens:
   a. Breaker Closing and Opening control
   b. Sequence of Operation screens with real time data: Step by Step operation instruction for connecting Shore Power to the Ship as well as disconnecting Shore Power from the ship which is animated along with single line diagram and instructions

4. HMI Substation Maintenance Screens
   a. Shore Power Outlet space heater monitoring via current relay monitoring space heater current.
   b. Substation Control Power Battery monitoring
   c. Load Interrupter Switch maintenance reminder alert from HMI triggered by Load Interrupter switch number of counter operation (a memory bit that is being incremented by Load Interrupter position I/O into the PLC
5. **HMI System Diagnostic Screens**
   
a. Multitask to program parameters settings on all protection relays, PLC, HMI, Power Monitor Ethernet Switch/Network Controller, GPS time Sync Receiver and etc.

b. Submit screen graphics and sequence of operation to the Engineer for acceptance.

c. Power system restoration instructional screens, including Step by Step instructions to put system back to normal operation status from a power outage situation.

6. **Acceptable manufacturers include:**
   
a. Wonderware
b. GE
c. Siemens
d. Rockwell
e. Approved equal

O. **GPS Clock:** Walk-in switchgear shall include GPS unit which provides date and time information to all data-logging and time stamped devices.

P. **Metal Enclosed Load Interrupter Distribution Sections:** Switchgear shall be integrated with Metal Enclosed Load Interrupter Distribution Sections as defined in Section 16343, *Medium Voltage Load Interrupter Switchgear*. The distribution sections shall be bus connected to the metal-clad switchgear described herein and shall have protected aisle walk-in shelter in front of the distribution sections.

Q. Each switchgear section shall have space heaters with space heater monitoring ammeters, sheaths and guards.
   
1. Space heaters of high-temperature chrome steel shall be provided to maintain temperature in accordance with manufacturer's tolerances inside the enclosure.

2. Each heater shall be rated 300W at 240VAC, for use at half voltage for long life which providing 75 watts for each heater equipment. Four heaters shall be mounted in each section, for a total of 300 watts per vertical section. Space heaters shall be wired and, along with space heater monitoring system controlled by thermostats and humidistats to guard against internal condensation.

R. **Bus voltage transformers**
   
1. Voltage transformers shall be or epoxy-encapsulated, with current limiting primary fuses.
2. Voltage transformers shall be Group 2 class for line-to-line or line-to-neutral connections as appropriate for the insulation class required. Primary voltage ratings and transformation ratios shall be as indicated. Voltage transformers shall have accuracy rating of not less than 0.3 Class at the standard burden imposed by the connected devices.

S. Provide grounding stud connection with pull-off rubber boot at all medium voltage cable entrance compartments.

T. Battery and Charger. The Battery charger shall be:

1. Microprocessor-controlled float type battery charger for use on a 125VDC PG&E approved battery. Battery charger shall be Hindle Industrial AT10.1 (or Engineer approved equal). The battery shall also have sufficient energy to sequentially charge 2 circuit breakers.

2. Sized by switchgear manufacturer to provide sufficient energy at 45°F for simultaneously opening two circuit breakers.

U. A permanent "DANGER HIGH VOLTAGE KEEP OUT" sign shall be attached to each exterior door.

V. Finish

1. All steel structure members shall be cleaned, rinsed, and phosphatized prior to painting.

2. The switchgear shall be painted with an electrostatically applied polyester powder with final baked on average thickness between 1.5 and 2.0 mils and meet ANSI requirements for outdoor equipment.

3. All exterior surfaces of the switchgear assembly shall be given final finish coats of ANSI 61 gray as standard.

4. Finish shall have a minimum pencil hardness of 2H as tested per ASTM D3363 and shall pass the ASTM B117 Salt spray test for a minimum of 1000 hours.

5. Touch-up materials - with complete instructions - shall be included with each shipment section of metal-enclosed switchgear for touch-up in the field.

W. Space heater monitor: Provide current sensor relays with a form-C contact for monitoring SPO space heaters.

X. "Horn Silence" and "Ship Ready" pushbutton shall be green, non-illuminated, NEMA 4/13 rated, momentary contact, flush head, 2.06 N.O. and 2 N.C. contacts. Allen-Bradley #800T-A1B or approved equal.
Y. "Breaker Lock" shall be a flush mounted key actuated switch (at HMI section) with 4 N.O and 4 N.C. contacts rated for 125VDC. When actuated the key shall remain captured.

Z. Emergency-Stop pushbutton shall be NEMA 4/13 rated 60mm illuminated red jumbo mushroom head, 2-position push-pull 2 N.O. and 2 N.C.L.B contacts with guard ring.

AA. Provide portable safety eyewash station with pressurized stainless-steel water canister.

AB. Provide one (1) 20-lb. 10-BC CO2 wall-mount fire extinguisher at each door location (2 total) per substation.

2.07 SOURCE QUALITY CONTROL

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

1. Production tests on completed switchgear assembly according to IEEE C37.71.

2. All switchgear, protection, control, monitoring and alarm functions on switchgear, protection relays, PLCs, and HMI operator panel shall be thoroughly tested and demonstrated to the Port for the Port’s acceptance.

B. 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.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer’s instructions.

B. Install on concrete pad as indicated on Plans.

3.02 FIELD QUALITY CONTROL

A. Perform field inspection and testing in accordance with Section 16080, Field Electrical Testing Requirements.

B. Inspect and test in accordance with NETA STD ATS, except Section 4.

C. Perform inspections and tests listed in NETA STD ATS, Section 7, Inspections and Test Procedures.
D. Perform Relay Tests as follows:

1. Configure and test relays and their associated instruments (CTs and PTs) using settings provided by the Engineer, and to comply with PG&E and designed shore power requirements. The Contractor shall provide a schedule to the Engineer listing the dates for relay and instrument testing within two weeks before the proposed test dates, to permit observation of the tests by the Engineer.

2. Provide a skilled certified relay technician actively engaged in the business of testing, configuring, and calibrating protective relays. Furnish all special equipment required and provide a test set with a current certified calibration label attached. Follow manufacturer's recommendation on testing for the microprocessor based relays.

3. Two relay wiring tests shall be made:
   a. Primary circuit polarity test shall include a DC test from the current transformer to each terminal block and relay terminal.
   b. Relay and circuit breaker operation test by application of power from the portable relay test set. Relay testing shall be accomplished using a standard portable test set and the relay manufacturer's testing instructions to demonstrate correct relay performance.

4. Test time-overcurrent relays to confirm that the time-overcurrent characteristic conforms to the manufacturer's published curves at the tap and time dial settings provided. Testing shall include (1) zero set test; (2) pick-up test; (3) time-overcurrent curve (operation at currents 3 and 4 times the tap setting and instantaneous pick-up) and target and seal-in operation.

5. Provide a card in each relay window indicating relay settings as tested, initialed by the testing technician.

3.03 START-UP-SERVICES

The switchgear manufacturer or the assembler of the manufactured parts must provide a qualified technician for equipment start-up services, under the direction of the Contractor after equipment is installed. The technician shall certify that the equipment has been installed, adjusted and tested in accordance with the manufacturer's recommendations.

3.04 TRAINING

See Section 16050, General Electrical Provisions, for training requirements.

END OF SECTION